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The Spatial Pattern of Deprivations in Addis Ababa and the Implications for Policy and Planning

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This is to certify that the dissertation prepared by Gizachew Berhanu Gelet, entitled "The Spatial Pattern of Deprivations and the Implications for Policy and Planning: Based on Citywide Scale and Informal Settlement Areas of Addis Ababa, Ethiopia," submitted in fulfillment of the requirement for the degree of Doctor of Philosophy in Urban and Regional Planning, complies with the regulations of the university and meets the accepted standards concerning originality and quality.

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I, the undersigned, declare and authenticate that this Dissertation is my own original piece of work and has not been presented for a degree in any other University. All sources of material used for the dissertation have been duly acknowledged, following the scientific guidelines of Addis Ababa University.

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Acronym

<i>AACPPPO</i>	<i>Addis Ababa City Planning Project Office</i>
<i>ABS</i>	<i>Asset Based Social policy</i>
<i>AE</i>	<i>Adult Equivalent</i>
<i>BTS</i>	<i>Bartlett's Test of Sphericity</i>
<i>ci</i>	<i>The variance explained by Component or factor with eigen value >1</i>
<i>cs</i>	<i>It is the sum of the variance explained by the components (c1 to cn) with eigen value > 1.</i>
<i>CIS</i>	<i>Corrugated Iron Sheet</i>
<i>CLVS</i>	<i>Congested Living and Vulnerable Social Groups</i>
<i>CSA</i>	<i>Central Statistics Agency of Ethiopia</i>
<i>CBO</i>	<i>Community Based Organization</i>
<i>CBD</i>	<i>Central Business District</i>
<i>ECE</i>	<i>Economic Commission for Europe</i>
<i>ESRI</i>	<i>Environmental System Research Institute</i>
<i>ENPC</i>	<i>Ethiopian National Planning Commission</i>
<i>EVIN</i>	<i>Environment and Infrastructure</i>
<i>IHDP</i>	<i>Integrated Housing Development Program</i>
<i>ILO</i>	<i>International Labor Organization</i>
<i>fi</i>	<i>Component or Factor Score of a Wereda. fi ranges from 1 to n</i>
<i>FDRE</i>	<i>Federal Democratic Republic of Ethiopia</i>
<i>FHHS</i>	<i>Female headed Households</i>
<i>HEPSV</i>	<i>Health, Social, and Physical Vulnerability</i>
<i>HHs</i>	<i>Households</i>
<i>HH</i>	<i>Household</i>
<i>HD</i>	<i>High Deprived</i>

<i>LHSS</i>	<i>Low Human Capital and Substandard Services</i>
<i>LISA</i>	<i>Local Index of Spatial Association</i>
<i>LSES</i>	<i>Low Socio-Economic Status</i>
<i>LR</i>	<i>Low Resolution</i>
<i>LRA</i>	<i>Logistic Regression Analysis</i>
<i>LULC</i>	<i>Land Use Land Cover Change</i>
<i>KMO</i>	<i>Keyser-Meyer-Olkin Measure of Sampling Adequacy</i>
<i>MHHs</i>	<i>Male Headed Households</i>
<i>MFA</i>	<i>Ministry of Federal Affairs</i>
<i>MOFED</i>	<i>Ministry of Finance and Economic Development</i>
<i>MOLS</i>	<i>Ministry of Labors and Skills</i>
<i>MUDH</i>	<i>Ministry of Urban Development and Housing</i>
<i>MUDHC</i>	Ministry of Urban Development, Housing and Construction.
<i>NCRM</i>	National center for research methods
<i>MDI</i>	<i>Index of Multiple Deprivations</i>
<i>ML</i>	<i>Machine Learning</i>
<i>MSSE</i>	Micro and Small-Scale Enterprises
<i>MSAT</i>	Multivariate Statistical Analysis Technique
<i>MUDH</i>	Ministry of Urban Development and Housing
<i>SRC</i>	Spear' man rank correlation
<i>PCA</i>	Principal Component Analysis
<i>PHSC</i>	<i>Poor housing services and congestion"</i>
<i>PPMC</i>	Pearson Product Moment Correlation
<i>OBA</i>	Object-oriented analysis
<i>OWAUV</i>	<i>One way analysis of variance for unequal variance</i>
<i>SDG</i>	<i>Sustainable Development Goal</i>
<i>SSA</i>	Sub Saharan Africa
<i>SBSM</i>	Survey-Based Slum Mapping
<i>SVM</i>	Support Vector Machine

<i>CNN</i>	Convulsion Neural Network
<i>RF</i>	Random Forest Classification
<i>ORAAMP</i>	<i>Office for the Revision of Addis Ababa Master Plan</i>
<i>UNDG</i>	United Nations Development Group
<i>UNDP</i>	United Nation's Development Program
<i>UNDESA</i>	United Nations Department of Economic and Social Affairs
<i>UPSNP</i>	Urban Productive Safety Net Program
<i>VHD</i>	<i>Very High Deprived</i>
<i>VHR</i>	<i>Very High Resolution</i>
<i>VUSG</i>	Vulnerable Social Groups

Abstract

The purpose of the research is to analyze, interpret, discuss, and emanate policy and planning implications from the different aspects of deprivation. The different aspects of deprivations include deprivations of sustainable livelihood capital assets, monetary and non-monetary aspects of the multiple deprivations, and urban morphology aspects of deprivations.

The research conducted for the interrelationship of deprivations of sustainable livelihood capital assets was an informal settlement area survey, key informant interviews, and an individual case study based on the informal settlement areas of Addis Ketema and Kolfe Keranyo sub-cities. The research reviewed the theoretical and empirical frameworks of poverty and informal settlement interventions. Then, the research analyzed and discussed the pattern of interrelationships between deprivations of sustainable livelihood capital assets, capability, and institutional aspects by triangulating with the deductive frameworks. This part of the research culminated with the proposal of an asset-based social policy for strategic issues from the analysis to be executed based on stages of asset accession, valorization, and transformation.

The research also justified the rationales of area-based policy for multiple deprivations by analyzing, discussing, and interpreting the overlaps and coexistence of a multitude of problems in space through multivariate analysis, the spatial pattern of inequality through tools of local indicators of spatial association, and the disproportional deprivation of large populations from spatial and statistical analysis of deprivation versus population size and density. The overall spatial pattern of deprivation indicators from monetary and non-monetary aspects revealed a pattern of a divided city, the polarization of poverty, and a large and vulnerable population that was multiply deprived. The research also developed a Multiple Deprivation Index (MDI) based on MDI 2007 and MDI 2016 for city-wide Addis Ababa that reflects the multiple deprivations faced by the urban poor and is used for resource allocation for compensatory policy and urban regeneration interventions. The research also suggested the integrated achievement of SDGs 1, 4, 8, and 11 for tackling multiple deprivations.

The research also demonstrated the relevance of urban morphology for analyzing and interpreting deprivations considering the conceptual level of slum ontology and the local context's definition of informal or formal settlement areas and housing based on very high-resolution imagery (VHR) for 2010 and 2022. As a result, the research indicated the magnitude of the effect of environmental factors on deprived areas using logistic regression analysis, delineated deprived (informal) and less deprived (formal) settlements based on settlement-level interpretation elements, and interpreted informal and formal buildings based on object-based random tree classification and quantification. As a result, the study quantified the extent and trends of deprived and less deprived areas for 2010 and 2022 from VHR. The study also interpreted and quantified deprived and less deprived buildings based on 2011 aerial photographs, using object-based classification. The study also computed the proportion of the population living in informal and formal settlements for 2010 and 2020. The aforementioned morphology-based deprivation is useful for monitoring SDG 11, prioritizing upgrading areas for curbing the challenges of urbanization, and computing the cost of deprived and less deprived buildings for neighborhood planning interventions.

Chapter one: Introduction

1.1. Background of the study

The spatial pattern is defined as the arrangement of individual entities in space and the geographic relationship among them" (Chou, 1995). Based on the above definition, the research focused on analyzing the different aspects of deprivations from the perspectives of sustainable livelihood capital assets, monetary and non-monetary terms, and urban morphology based deprivations.

Many of the previous theoretical frameworks, urban policies, and interventions in Ethiopia do not explore the whole range of deprivations in livelihood capital assets, though the livelihood of the poor depends on asset mobilization. The above situation leads to policy failure on informal settlement interventions and holistic improvement of the livelihood of the poor. Considering the preceding background, the study examined the relationship between the deprivations of sustainable livelihood capital assets, capability, risks, and institutional aspects, and suggested asset-based social policy (ABS) implications for strategic choices that call for intervention. The Addis Ketema sub-city of Wereda 07 (the inner-city slum) and the Kolfe Keranyo sub-city of Wereda 03 (peri-urban) were the study areas. As per theoretical and empirical frameworks, the study examined the pattern of relationships between the deprivations of sustainable livelihood capital assets and the variations in subgroup deprivation in Addis Ababa's informal settlement areas, and it came up with recommendations for ABS. The study examined the methods used in interventions in informal settlements regarding livelihood capital assets, the inter- and intra-individual effects of one livelihood capital asset deprivation on another, the connections between assets and the function of capability, and the function of institutions in facilitating access to and use of these assets.

The ABS intervention also considers the triangulation of analysis with deductive theoretical and empirical frameworks. The study suggested enhancing institutions to bring livelihood capital assets closer to deprived and vulnerable subgroups, empowering community associations to advocate for the rights of the underprivileged, strengthening capability functioning for the

accumulation of livelihood capital assets, and reducing deprivations in holistic forms. ABS is a crucial tool for resolving the strategic issue of livelihood capital asset deprivation, addressing institutional and legal restraints, ensuring the effectiveness of assets and capabilities, and mitigating risk, safety, and security. The ABS policy improves the well-being of poor, deprived, and vulnerable sub-groups through asset accession, valorization, and consolidation stages.

The study also analyzed multiple deprivations and spatial inequality at a city-wide scale based on data from the census, survey, base maps, and aerial photographs. The overlaps of multiple deprivations are validated with the overlaps of multiple deprivation indicators and components as well as the spatial pattern of inequality and deprivation. The relationship between deprivation and population size and density on a city-wide scale, as well as the failure of sector-based policy for reaching deprived populations based on World Bank projects experience, reinforce the pertinence of compensating the poor by area-based policy to reduce socio-spatial inequality as well as ensuring better prioritization of people-based policy. Ethiopia in general and Addis Ababa should curb the challenges of Ethiopia's urbanization, notably poverty, unemployment, informal settlements, a severe housing shortage, and environmental dangers, which are related to multiple deprivations and poverty. The MDI was created as a monitoring tool using a multitude of deprivation indicators and components for the years 2007 and 2016. The MDI tool can be used as a fiduciary disbursement for compensatory area-based policies. The area-based strategy using MDI, however, has been impractical in Ethiopia for a long time, which reinforces the polarization of poverty and geographic inequality and generates a divided city. The findings of the deprivations and inequality patterns were triangulated and validated with the deductive theoretical, empirical, and SDG (Sustainable Development Goal) frameworks to replicate external validity. A combination of descriptive and correlational methodologies was used in the research design. Spatial inequality and poverty polarization were revealed by the inductively derived pattern using PCA (principal component analysis) and LISA (local index of spatial association) of MDI components. Global spatial autocorrelation revealed an index of concentrated poverty on a city-wide scale. Concentrated poverty was found via statistical and spatial trend analysis, especially in inner-city slums and peri-urban informal settlements. The examination of MDI indicators and components revealed additional slum indicators and the relevance of integrating other SDG indicators with SDG 11 for realizing sustainable urbanization, while most of the findings were consistent with deductive theoretical and SDG

frameworks. The study justified area-based policy for reducing poverty due to geographic disparity, patterns of concentrated poverty, a substantial, impoverished population, and alleviating future urbanization challenges.

The contemporary trends for analyzing deprivations are characterizing the properties and extent of deprivations using cost-effective remote sensing imagery. Based on SDG 11, addressing housing inadequacy problems requires geospatial technology. Therefore, based on the local definition of informal settlement coupled with the concept of the slum ontological framework, the deprivations were analyzed at the environment, settlement, and object levels. At the environmental level, logistic regression analysis (LRA) was performed to predict the magnitude of the effect of the environment-level indicators on deprived areas for 2010 and 2022. At the settlement level, deprived areas were delineated for 2010 and 2022, with further verification of 113 sample survey points deriving extent and growth trends for 2010 and 2022. Then the population was estimated for 2010 based on the 2010 settlement area, and the population for 2020 was estimated based on the 2022 settlement area. At the object level of the building, two deprived and two less deprived areas were selected by convenient sampling for object-level identification using RF (random forest classification). Based on the environment-level analysis, a settlement near the riverbank and high population density predicted deprived areas, while for 2022, the predictors were settlements near the riverbank, slope areas, and crop areas. In 2022, the high population density was no longer a predictor or driving force with its contemporary compact, formal-driven morphology.

According to settlement level analysis, the deprived areas accounted for 50% (2010) and 46% (2022) of residential land use, growing at an annual rate of 2.679% between 2010 and 2022. The above figure turned out to be low compared with the less deprived [formal settlement] annual growth rate trends (4.564%). The population living in deprived areas [informal settlements] was 68 % in 2010 and 54 % in 2020. Addis Ababa has started to address SDG target 11.1.1 of decreasing the proportion of the population living in slum areas, but so much more needs to be done to decrease the absolute growth of the slum population. The study found that informal buildings can be identified based on roof color and shape, coupled with neighborhood information, with a substantial kappa coefficient. The above findings indicated that object-based

classification is useful for realistic upgrading interventions for differentiating deprived and less deprived buildings.

1.2. Statement of the problems

From the perspective of sustainable livelihood capital asset interventions, the paradigm of the urban planning discourse has contributed to reducing challenges with informal settlements, socio-spatial exclusion, and deprivation (Abram, 1966; Turner, 1982; De Soto, 2001; Payne, Rakodi, and Durand-Lasserve, 2009; Arroyo, 2013; Fontana, 2016). The theoretical frameworks, such as the bid-rent model, livelihood capital assets, and growth machines, had implications for poor access, security, survival, consolidation, and control over livelihood capital assets and poverty alleviation (Lewis, 1966; Logan, 1976; McLeod, 2001; UN-Habitat, 2003a; Morse and McNamara, 2013; Serrat, 2017). The theoretical framework on social exclusion, asset social preference, and capability had implications for access and control of assets by the poor and sub-groups (Sen, 1995; Iverson & Soskice, 2001; Levitas, 2006; Levitas, Pantazis, Fahmy, Gordon, Lloyd, & Patsios, 2007; Lasse, 2011).

The inadequate understanding of pervasive problems in informal settlements leads to dealing with the different aspects of deprivation independently (ECE [Economic Commission for Europe], 2008); therefore, many of the past urban policies and interventions failed to consider the holistic deprivations of sustainable livelihood capital assets and the multifaceted nature of poverty. The inclusive, integrated, and resilient approach requires designing strategies and policies for informal settlement reduction and housing interventions that consider the range of livelihood capital assets and the rights of the poor (Soma, Sukhwani, & Shaw, 2020; UN-Habitat, 2020a; Wang, Lan, & Wang, 2021a). In countries in sub-Saharan Africa (excluding South Africa), 95% of the population depends on the informal sector (Florence, Vanek, and Chen, 2019). Since most poor people in informal settlements do not depend on salaried employment: their livelihoods and well-being rather depend on their ability to access and accumulate assets, earn a decent return from these assets, and use the asset base to manage risks (Moser & Dani, 2008). Asset mobilization is the key to reducing risk and vulnerabilities (Vatsa, 2004) and informal settlement interventions. Yet, neither urban restructuring programs nor interventions in informal settlements have been designed to promote the poor's control over and access to sustainable livelihood capital assets in Ethiopia (Lakisha, 2012; MFA [Ministry of Federal

Affairs], 2005; MUDHC [Ministry of Urban Development, Housing, and Construction], 2003; UN-Habitat, 2011; Kloosterboer, 2019).

Several researchers argued for the interrelationship between livelihood capital assets and their relevance to livelihood strategies of poverty alleviation and sustainable urbanization (Sheilah, Tamsin, and Julian, 2001; Farrington et al., 2002; Baud, Pfeffer, Sridharan, and Nainan, 2009; UNDP, 2017; SDG [Sustainable Development Goal] Tracker, 2019; Wang, Li, Jin, Yao, & Ji, 2021b). The deprivations in sustainable livelihood capital asset interrelationships implicated the crucial role of asset accumulation through the functioning of capability. Poverty is viewed as the deprivation of basic capabilities (Sen, 1995). The capability approach focuses on what people can be and do with the resources and goods (Robeyns and Morten, 2021). Individuals and communities are crucial to the expansion of capabilities (Graciela, 2018). The greater the erosion of people's assets, the greater is the vulnerability and insecurity (Lienert & Burger, 2015). Accordingly, ABS shifted from income/consumption to the critical role played by assets and capability in improving well-being (Moser, 2008). The first generation focuses on asset accumulation while the second generation focuses on asset consolidation (Caroline and Moser, 2006). The ABS accumulates assets through stages of asset accession, valorization, and transformation (Dani & Moser, 2008; Moser, 2008).

In the context of Ethiopia, UPSNP (Urban Productive Safety Net Programme) intervened in asset accumulation, capability functioning, food security, and risk aversion (Gebreselassie, 2019; Abiy, 2020). MSSE (Micro and Small-Scale Enterprises) is working in Ethiopia to improve the functioning capabilities of the poor, but problems with revolving fund recovery have stunted its development (Nega & Edris, 2016). Yet, despite Ethiopia having a national social protection policy in 2012 (MOLS [Ministry of Labor and Skill], 2012), the number of people receiving social protection benefits in Ethiopia was 7.4% [low relative to Africa's average of 17%] (ILO [International Labor Organization], 2021).

The different sub-groups (gender, age, HH types, and employment status) varied by deprivations in access to resources, rights, goods, and services in line with the social-exclusion theory (Levitas, 2006). Several researchers argued in favor of or against the variation of deprivations or poverty by sub-groups (Jayamohan and Amenu, 2014; Aboderin, Kano, and Owil, 2017; FDRE [Federal Democratic Republic of Ethiopia], 2018). People's capabilities also varied in what they were able to do and be with those resources (Robeyns & Morten, 2021), which needs

consideration for sound ABS policy. Institutions affect the range of livelihood capital assets by controlling and influencing how, when, and by whom they are used (Messer & Townsley, 2003; Dani & Moser, 2008; Carloni & Crowley, 2005; Shahbaz, Vinod, Geiser, Sadaf, Scharer, and Müller-Boker, 2010; Serrat, 2017; UNDP, 2017; Bebbington, n.d.). In sum, the interrelationship among deprivations of sustainable livelihood capital assets and sub-group variations in deprivations provides core strategic issues given the extent of the relationship, which requires interventions in ABS. Thus, it is crucial to analyze the role of institutions in the control and access of livelihood capital assets by sub-groups and the functioning of capabilities for a realistic ABS policy.

Current research conducted on urban livelihood includes assessments of the impact of urban expansion on the livelihood of the poor, migration as a livelihood option, and substantiating the relevance of livelihood capital assets for curing urban poverty (Amphune, Weldegebiel, and Enaro, 2018; Yirga, 2021; Talema, 2023). Yet, there is a research gap in Ethiopia on designing asset-based social policy and informal settlement interventions for realizing sustainable urbanization based on sustainable livelihood capital asset interrelationships, assessments of capability, and institutions. The study analyzes the pattern of the interrelationship between deprivations of livelihood and capital assets, including sub-group variations. Then, strategic issues are refined from the preceding analysis, considering the assessments of capability functioning, risks, and the institutional role in the control and access to livelihood capital assets. Finally, the study recommended ABS for asset accession, asset valorization, and transformation for alleviating poverty and making sound informal settlement interventions. The research is intended to be conducted in chronically poor neighborhoods of Addis Ababa, refined based on the slum dichotomy model of Stoke (1962).

The overall pattern of multiple deprivations is crucial for area-based compensatory policies, which prioritize and address deprivations and socio-spatial inequality. Area-based targeting is logically justified based on the following conditions: For nations with a high level of urbanization, divided cities, significant regional differences, and small economies cut off from the global market (Turok, 2013). The area-based policy is also substantiated in areas with an overlap or coexistence of problems, such as spatial inequality, reaching large, deprived populations, bringing social and spatial justice, reaching vulnerable groups, and reducing

residential segregation (Smith, 1999; Tunstall and Lupton, 2003; Crane and Manville, 2008; Turok, 2013; Hohmann, 2014).

Regarding Ethiopia's urban context, the annual rate of urban growth in Ethiopia is 5.4% (MUDH [Ministry of Urban Development and Housing], 2015; World Bank Group and Cities Alliance, 2015), which is a fast growth rate and evidence of increasing urbanization trends in the future. Addis Ababa is a divided city. Addis Ababa depicts the clustering of deprivations in informal settlements and slums, with fewer opportunities for dwellers, poor infrastructure or services, and substandard and deplorable housing. If people are not given access to opportunities, services, and a better life, the development will not be sustainable and socio-spatial inequality will remain a rampant challenge for future urbanization. Moreover, reducing inequality by age, sex, disability, race, ethnicity, and the economy is a goal of SDG 10 (UNDESA [the United Nations Department of Economics and Social Affairs] and the World Bank Group, 2019). Due to concentrated poverty, spatial inequality in SSA (Sub-Saharan Africa) and Ethiopia has not greatly decreased over the past decade (Shifa and Leibbrandt, 2021). Urban inequality in Ethiopia increased from 0.29 in 1995 to 0.37 in 2010–11 and rose marginally to 0.38 in 2015–16 with more people living in cities.

Urbanization in Ethiopia has not been correlated with a corresponding rise in economic prosperity. In Addis Ababa, nearly 1/4th of Addis Ababa and about 1/3 of the inner-city slum of Addis Ketema reported having an adult without a job (World Bank Group and Cities Alliance, 2015; Berhanu, Weldemikael, and Beyene, 2022). Despite 65.7% pro-poor spending in 2015–16, the non-monetary benefit saw only modest reductions (ENPC [Ethiopian National Planning Commission], 2017; World Bank Group, 2020a). In Ethiopia, 88% of the people are multidimensional poor (UNDP Ethiopia, 2018), and large HHs, a high dependency rate, and a lack of education are the main characteristics of poor people in Ethiopia (World Bank Group, 2020b).

The preceding findings implicated the consideration of monetary and non-monetary aspects of deprivations. Deprivation methodology, indexes, and research have been performed in the global north experience and South Africa (Coombes and Raybould, 1989; Andrea, 2012; Deas, Robson, Wong, Bradford, 2003; McLennan, Noble, Noble, Plunkett, Wright, Gutacker, 2019; Glassman, 2019; UN-Habitat, 2020c; Noble, Babita, Barnes, Dibben, Magasela, Noble, Ntshongwana, Phillips, Rama, Roberts, 2006; Patel, Shah, Beauregard, 2020). Nonetheless, little research has

been done so far in Ethiopia and SSA to develop disaggregated small area-level monitoring tools, factors, and indicators for urban deprivations, as well as better target resources for vulnerable or prioritize urban regeneration areas.

Ethiopia should achieve SDG target 1.2 to reduce all dimensions of poverty by half (SDG, 2019). Therefore, an MDI tool that weighs multidimensional problems is crucial. The MDI links and tracks SDGs because it evaluates and weighs a broad spectrum of problems. By implementing programs or projects using MDI, the gap in spatial inequality and deprivation will be lessened by targeting the vulnerable population. Nonetheless, the majority of SSA nations are not exploring the MDI for resource allocation and priority setting. Notwithstanding the vast and disproportionately poor population and pervasive spatial inequality, Addis Ababa allocates a capital budget for sub-cities based on a sector-based approach that takes the unit cost of the project, population, and level of development into account (FDRE, 2020). One reputed empirical method for creating an index (MDI) that considers the multidimensional pattern of poverty encountered by the urban poor is the Multivariate Statistical Analysis Technique (MSAT). The sub-objective of the research is to refine the most important factors and indicators explaining the multiple forms and patterns of deprivation using MSAT.

Uneven distributions of income, resources, and infrastructure cause spatial inequality (Kanbur and Venable, 2005). Inequality is greater in urban than rural areas of Ethiopia (Debebe and Zekarias, 2020). As evidence of the severe social inequality and social exclusion, Ethiopia's lowest 10% have not seen income growth since 2005 (UNDP Ethiopia, 2018; World Bank Group, 2022). In urban areas, since the poor and vulnerable are concentrated in slums and informal settlements while the wealthy are mainly partitioned into formal neighborhoods, spatial inequality, and poverty polarization are unavoidable facts. Eighty percent of Addis Ababa's inner city is made up of slums (UN-Habitat, 2017). In Addis Ababa, informal settlements account for 44% of the city's built-up area and are home to 66% of the inhabitants (World Bank Group, 2008).

Area-based policy targeting is logical for Addis Ababa, a city with a high population growth rate, and noticeable spatial disparities in access to decent housing and essential urban services, as evidenced by its persistently high unemployment rates, alarming poverty incidence, and apparent proliferation of informal settlements (MUDH [Ministry of Urban Development and Housing], 2015; World Bank Group and Cities Alliance, 2015; Turok, 2013). The non-monetary

components of welfare (education, health, access to water, and sanitation) are still low in Ethiopia (UNDP, 2018). There is a substantial investment in anti-poverty programs, especially in UPSNP interventions (ENPC, 2017; World Bank Group, 2021). Yet, there have not been remarkable improvements in non-monetary aspects of deprivation in Ethiopia. To better target limited resources and prioritize highly deprived areas, it is crucial to integrate pro-poor spending with geographically disadvantaged welfare areas. Thus, the sub-objective of the study intends to analyze the spatial pattern of deprivations and inequality based on components of multiple deprivations. The spatial analysis and mapping provide a holistic picture and pattern regarding where resources and investment should be located to curb deprivations, as well as indicating the degree of polarization of poverty and spatial inequality.

Area-based targeting offers completeness and efficacy in the case of the spatial concentration of poor individuals (Tunstall and Lupton, 2003), since targeting and prioritizing are easier in relation to dispersed poverty. Area-based targeting reduces the negative neighborhood trans generational effect of poverty traps by providing public goods and funding rationing (Crane and Manville, 2008). Since the area-based strategy prioritizes areas for delivering economic resources and social protection measures to accomplish SDG 1, it complements the people-based approach (SDG, 2018; World Bank, 2022). However, vulnerable people are abundant and disproportionately overcrowded in Addis Ababa's slum areas (World Bank Group, 2008; Elias, 2008), while the affluent are mostly restricted to formal neighborhoods, resulting in a divided city. For Addis Ababa, the purely inner-city slum sub-cities accounted for 32.5% of the 2016 projected population (CSA [Central Statistics Agency of Ethiopia], 2013a), which was concentrated in 7.8% of the Addis Ababa area. The overall inner-city slum accounted for 40 percent of the population and 11 percent of the area of Addis Ababa (Weldeghebrael, 2022), validating the fact of concentrated poverty.

In addition, the city periphery of Addis Ababa houses mainly impoverished and enormous rural migrants, who acquire land through informal land transactions (Bundervoet, 2018; Berhanu et al., 2022). Yet, there are also some inner-city unofficial housing constructions or 'meteleya' (Elias, 2008; Issa, 2021) and temporary and recent migrants in parts of the inner-city slum (Berhanu et al., 2022), reflecting Turner's (1976) mobility theory. Due to concentrated poverty, informal dwellers housed a large and highly overcrowded poor population—as many as

35% of the residents of the inner-city slum dwell in single-room accommodations (Habitat for Humanity Great Britain, 2017). The current housing crisis in Addis Ababa is due to the mounting rural exodus to Addis Ababa triggering urbanization (Habitat for Humanity Great Britain, 2017; Bunderovet, 2021). The theoretical frameworks substantiate the relationship between the pattern of concentrated poverty and population in the context of the global North from the perspectives of suburbanization of urban jobs, the center versus suburban location, deindustrialization, income, and race-based residential segregation (Wilson, 1987; Sheih, 2003; Narvaez, Penn, Griffiths, 2022).

In Ethiopia, a theoretical framework claimed that concentrated poverty is higher in urban forms such as inner-city slums and peri-urban areas, while it is lesser in intermediate areas (Tesfaye, 2019). The empirical findings from the 122 poverty-targeted social programs of the World Bank showed that 25% of sector-based spending benefits the wealthy. (Van Domelen, 2007). The preceding justifications point to the need for a policy framework, tools, and budget to better target vulnerable populations (SDG, 2018) living in high-poverty areas. The analysis of locations with large, disproportionately deprived populations will assist in justifying the need for compensatory area-based policy to reach the more deprived populations and address their preferences through participation and partnership. Based on the preceding framework, the study sub-objective intends to justify the appropriateness of area-based policy by analyzing and discussing the proportion of the deprived population for the city as well as the statistical and spatial relationship between population density and the deprived population.

The research intends to develop MDI for 2007 and 2016. The basis for MDI 2007 is extracting information from the Addis Ababa census row data provided by the CSA. The basis for MDI 2016 is analyzing the row data of Addis Ababa expenditure and the socio-economic survey of the CSA for 2016. In addition, the MDI 2016 uses the existing land use and roads of the 2017 structure plan and buildings from the 2010 Addis Ababa aerial photograph from the Addis Ababa city administration. The study also uses the population projections for Addis Ababa in 2016 (CSA, 2013a).

Addressing physical deprivation is on the agenda for SDG 11, as is tackling the challenges of the future urbanization of Ethiopia. In the SDG target [11.1.1], the focus area is the percentage of the

population living in slums, informal settlements, or inadequate housing (United Nations, 2023a). Regarding global trends, world urbanization exceeded 50% (Liddle, 2017; Jones, 2017). The slum incidence exceeded by more than twice the urbanization rate (United Nations, 2023b). The urbanization increased the absolute number of poor people (UN-Habitat, 2016; SDG, 2018; UN-Habitat and Global Urban Observatory, 2019; UNICEF and UN-Habitat, 2020). The rapid urbanization of developing countries increased the absolute number of poor people (UN-Habitat, 2016; SDG, 2018; UN-Habitat and Global Urban Observatory, 2019; UNICEF and UN-Habitat, 2020). Poverty is increasingly urbanized and manifests through high living costs, limited services, and social marginalization (UNDG [United Nations Development Group], 2012). Unplanned rapid urbanization is associated with the proliferation of deprived areas in low- and middle-income countries (UN-Habitat, 2016; Tjia & Coetzee, 2022). The urbanization of poverty, combined with unequal resource distribution and anti-poor policies, leads to rising urban poverty (UNDG, 2012). In 2035, most of the world's extremely poor will live in urban areas, and urban centres will become the epicenter of multidimensional poverty (UNDP, 2016). Ethiopia is no exception to multidimensional poverty prevalence in urban areas, which is aggravated by the high annual urbanization rate of 5.4% (World Bank Group and Cities Alliance, 2015) and the prevailing challenges of urbanization (MUDH, 2015).

Sustainable urbanization requires averting the challenges faced by cities through structural transformation (McCormick, Neij, and Anderberg, 2012). The structural intervention requires consistent, detailed, and accurate geospatial information on deprived areas (Tjia & Coetzee, 2022). Yet, the area, extent, and population of informal settlement in Addis Ababa and other urban centers did not have a realistic figure, and the existing figure of informal settlement is obsolete. Currently, morphological patterns from VHR (Very High Resolution) are the basis for interpreting and analyzing the degree and patterns of deprivations (Kohli, Sliuzas, Kerle, Stein, 2012a; Kuffer, 2017; Abascal, Rodriguez-Carreno, Vanhuysse, Georganos, Sliuzas, Wolff, Kuffer, 2022). The deprivation area provides the basis for estimating the informal settlement population (Kuffer, Thomson, Boo, Mahabir, Grippa, Vanhuysse, Engstrom, Ndugua, Makaku, Darin, Albuquerque, and Cabaria, 2020). The informal settlement definition of Ethiopia provides the local context base for identifying deprived areas, coupled with Kohali et al.'s (2012a) concept of slum ontological frameworks. In the context of Ethiopia, informal housing refers to housing that breaches building standards and regulations (Mahiteme 2007; Mahiteme, 2014).

Different approaches, including manual delineation, surveying, and machine learning (ML), have been devised to identify deprived areas. Studies compare pixel versus object-based detection for deprived areas (Abascal et al., 2022), and other authors argue for the combination of SBSM (survey-based slum mapping) and object-based approach (Leonita, Kuffer, Sliuzas, and Persello, 2018; Kuffer et al., 2020). Researchers designed the conceptual ontological framework to identify informal settlements at the environment, settlement, and object levels (Kohli et al., 2012a; Fallatah, Jones, and Kohli, 2018).

The environment is the broadest level at which to characterize informal settlements. The location of deprived areas was related to environmental hazards (De Risi, De Paola, Jalayer, and Lervolina, 2013; Veriah, 2018; Kuffer et al., 2020; Muller, Taubenbock, Kuffer, and Wurm, 2020). Other research related neighborhood characteristics at the environmental level to deprived areas (Sliuzas & Kuffer, 2008; Baud, Kuffer, Sliuzas, and Karuppannan, 2010; Hacker, Costa, Seto, Jason, Mitermayer, Ko, and Diuk-Wasser, 2013; Kuffer, 2017; Fallatah et al., 2018). Other researchers related land use and land cover (LULC) and change analyses to deprived areas (Oyinloye, Owoeye, and Ogunlade, 2018; Abebe, Derebew, and Gemed, 2019; Matarira, Mutanga, Naidu, and Mushore, 2023). Deprived areas were identified by relating features from LR and VHR images (Fallatah et al., 2018; Fallatah, Jones, Wallace, and Mitchel, 2022). Researchers investigated the relationship between informal settlement and health (Weimann & Oni, 2019). In Addis Ababa, informal settlements are lying along the river, crop areas, high slopes, and religious places (Azagew & Werku 2020; African Development Bank Group and Municipal Development Fund, 2021; Bikis & Pandey 2022). Yet, currently, population density has increased not only in informal but also in formal settlements in Ethiopia. (Zewdie, Worku, and Bantider, 2021; Weldegebriel, Assefa, Janusz, Tekalign, & Van Rompaey, 2021). Yet, despite the fact that most countries have studied the relationship between the environment and deprived areas, as elaborated in the above literature, no research has been conducted in Ethiopia on the explicit relationship between the environment and deprived areas. Based on the preceding background, the sub-objective of this study intends to analyze whether the neighborhood environmental variables explain deprivation areas, identified based on urban morphology properties.

By tailoring the slum ontological frameworks of Kohli et al. (2012a) to local conditions, the manual approach delineates the major categories of formal and informal settlements by exploring

the human capability of recognizing subtle variations (Lilford, Kyobutungi, Ndugwa, Sartori, Watson, Sliuzas, and Ezeh, 2012). Organic layout, small building size, and building density characterized informal settlements, while formal settlements were characterized by inorganic layout (Lemma, Sliuzas, & Kuffer, 2006; Sliuzas & Kuffer, 2008; Kuffer, 2017). Furthermore, researchers differentiated old and newer informal settlements based on building density, land use heterogeneity, ecosystem service supply, and settlement stages (Sori 2012; Kuffer 2017; UN-Habitat 2017; Arif, Ahsan, Devisch, and Schoonjans, 2022). The ground verification of 113 sampled points enriched the delineation from 2010 aerial photographs and 2022 Google images. Addis Ababa has three types of informal settlements. Several authors elaborated on the peculiar characteristics of slums, regularized informal settlements, and peri-urban informal settlements (Tarekegn, 2000; Minwuyelet, 2005; Lemma et al., 2006; Kassahun, 2010; Hailu, 2016; Erena, Berhe, Mammaru, and Soresa, 2017; Berhanu et al., 2022). Yet, research has not been conducted pertaining to deprived areas and populations in Addis Ababa, and the existing information is obsolete. Based on this ground, the study intends to interpret deprivation from morphological aspects as well as the growth trends (2010–2022) of deprived and less deprived areas and inadequate housing as bases for estimating informal areas and forecasting populations to monitor the status of Addis Ababa regarding SDG 11.

Deprived and less-deprived buildings are identified at the object level through ML. The object-oriented analysis (OBA) of slums identifies impervious and permeable surface properties and characteristics (Fallatah et al., 2018) for scrutinizing deprived properties in depth and estimating the cost of upgrading. OBA outperforms settlement-level identification for detecting large formal buildings located in informal settlement areas (Leonita et al., 2018; Kuffer et al., 2020), which makes it useful for the pragmatic upgrading project. OBA outperforms pixel-level identification in image detection and classification (Thomas, Hendrix, and Congalton, 2003; Mathenge, 2011; Gram-Hansen, Helber, Varatharajan, Azam, Coca-Castro, Kopackova, and Biliniski, 2019), though computationally costly (Leonita et al., 2018; Kuffer et al., 2020). The rationale is that OBA derives spectral, textural, semantic, topological, and contextual information (Desheng & Fan, 2010; Fallatah et al., 2018; Jiayi, Xin, Lilin, Tao, Huang, and Leigunag, 2022). Yet, OBA extraction faces difficulty in accurate extraction based on the properties of pixel and settlement types (Huang, Tang, Xu, et al., 2022; Abascal et al., 2022), and other deep learning algorithms are also better for building extraction (Kuffer, Grippa, Persello, Taubenböck, Pfefer, Sliuzas, 2022; Abascal et al., 2022).

From OBA, the study used RF mainly due to working with multiband imagery and low pixel-wise uncertainty prediction (Breiman, 2001; Guo, Zhang, Luo, and Yang, 2020; Fisher, Gibson, Abdar, Posa, Salimi-Khorshidi, Hassaine, and Rahim, 2022; ESRI [Environmental System Research Institute], 2023). OBA performs coupled with the local context interpretation elements (Kohli et al., 2012a). The OBA classification, using RF, is performed on the late 2010 aerial photograph (20 by 20 m), provided by the Addis Ababa city administration. OBA was tested in four selected settlements in Addis Ababa. The chosen settlements were the Addis Ketema sub-city (slum area), Akaki Kaliti sub-city (Kebele 07 peri-urban informal settlement), Bole sub-city (Kebele 02 [intermediate formal settlement], and Kolfe-Keranyo sub-city (Kebele 02 expansion area formal settlement). The sub-objective of this study is to identify the interpretation elements distinguishing deprived objects (informal buildings) from less deprived objects (formal buildings). The interpretation elements were land use proportion, land use diversity, built-up density, and building features (roof size, roof color, and roof shape). The neighborhood characteristics include road shape and color (paved and unpaved), open space, and vegetation (trees and grass). The object classification accuracy assessment is also verified based on the kappa coefficient, error of omission, and commission.

1.2. Objective of the study

1.2.1. General Objective

The research's general objective is to analyze and discuss the pattern of deprivations from different aspects and suggest pertinent policy and planning implications for curbing deprivations and inequality.

1.2.2. Specific Objectives

Specific Objective-1: to analyze and discuss the pattern of deprivations in sustainable livelihood capital assets, sub-group deprivation variations, capabilities, risks, and institutional aspects, and propose asset-based social policy for strategic issues.

Specific objective-2: to substantiate whether area-based policy is rational for deprivations by justifying the overlaps of problems based on the main factors and

indicators of deprivations, justifying the spatial inequality based on the spatial patterns of the main components of deprivations, and examining the deprivations of large populations by interpreting the pattern of relationship between deprivation and population size and density.

Specific Objective-3: to demonstrate urban morphology-based deprivations based on the concept of slum ontology by analyzing the relationship of environment-level indicators with deprivations, interpreting the morphological characteristics of deprivations at settlement and object levels, and analyzing the area extent and growth trends of deprived settlement areas.

1.3. Research questions

The research questions are stated in line with the specific objectives as indicated below.

The research questions for objective 1:

1.1.) is there a pattern of the interrelationships among deprivations of sustainable livelihood capital assets, based on the findings triangulated with the theoretical and empirical frameworks?

1.2) are there variations in deprivation of sustainable livelihood capital assets by sub-groups based on findings triangulated with the theoretical and empirical frameworks?

1.3) What are the proposed asset-based social policy (ABS) interventions considering the sustainable livelihood capital asset deprivation interrelationship, sub-group deprivation variations, the assessment of risk, institutional, and capability aspects?

The research questions for objective 2:

2.1) "Which deprivation indicators are most strongly correlated with the main factors or components of the MDI (multiple deprivation index)?"

2.2) "Where are the highest and lowest deprivation concentration kebeles (neighborhood units) of Addis Ababa based on the spatial pattern of MDI components?"

2.3) "What proportions of the sub-city population of Addis Ababa were most deprived?"

2.4) "Are there statistical correlations and spatial relationships between the MDI deprivation score and population density in Addis Ababa?"

The research questions for objective 3:

- 3.1) "What are the extent and growth trends of deprived and less deprived settlement areas in Addis Ababa for 2010 and 2022?"
- 3.2) "What morphological properties distinguish deprived areas from less deprived areas based on 2010 and 2022 Very High Resolution (VHR) images of Addis Ababa and the settlement level slum ontology concept?"
- 3.3) "What morphological interpretation elements distinguish the deprived object (informal building) from the less deprived object (formal building) for sample areas of Addis Ababa based on the slum ontology concept at the object level?"
- 3.4) By what magnitude do the environment-level independent variables predict the 2010 and 2022 deprived status of residential areas in Addis Ababa?

1.4. Scope of the study

The geographic scope of the study is divided into three parts: the informal settlement selected area of Addis Ababa (by multistage sampling), the Addis Ababa city-wide jurisdiction study, and four selected areas of Addis Ababa (convenient sampling). Yet, a major part of the study was conducted in Addis Ababa city jurisdiction and selected informal settlement areas.

1.4.1. Informal settlement area

At informal settlement area levels of Addis Ababa, the study analyzed the interrelationships of deprivations in sustainable livelihood capital assets and their sub-group variations, as well as the implications for ABS based on the informal settlement areas. The "informal settlement areas" for the inner-city slum were selected from the sub-city of Addis Ketema, Wereda 07 (hereafter called the "inner-city slum), and Kolfe Keanyo, Wereda 03 (hereafter called the "peri-urban).

1.4.2. Addis Ababa city jurisdiction

In Addis Ababa city jurisdiction's level, the study analyzed deprivations and spatial inequality pattern by analyzing the interrelationship of indicators and factors. Moreover, the urban morphology-based deprivations were analyzed in Addis Ababa city jurisdiction at environment and settlement levels. The study was conducted at Addis Ababa's study jurisdiction level, including the ten sub-cities and their corresponding 99 kebeles. The study analyzed the spatial

pattern of deprivations and inequality and the urban morphology aspects of deprivations (for environment and settlement level analysis) for the city-wide Addis Ababa. The content studied at a city-wide scale included the overlaps and coexistence of a multitude of problems in space based on the indicators and components of MDI, the spatial patterns of deprivation and inequality, and the disproportional deprivation of a large and concentrated population. The study justified the findings by developing MDI 2007 based on the 2007 Ethiopian census and MDI 2016 based on CSA household expenditure and socio-economic survey, existing land use of the 2017 structure plan, and cadaster building from 2010 aerial photographs. The study also developed population density based on the 2007 census and 2016 CSA population projection.

Furthermore, the study analyzed deprivations on a city-wide scale from urban morphology angles and analyzed the extent of the deprived area (informal settlement) using high-resolution images of 2010 aerial photographs and 2022 Google images. The study also used ground verified low-resolution LULC images of Addis Ababa developed by ESRI from Sentinel 2. The study also extracted LULC from the 2013 Landsat 8 images. The study also extracted slopes and rivers from the 30-meter digital elevation model. The study also used the spatial distribution population data for Addis Ababa for 2010 and 2020.

1.4.3. Two informal and two formal selected areas of Addis Ababa: for object-based urban morphology-based deprivation analysis

The study selected two informal settlement areas by convenient sampling for object-level multicolor detection of deprived buildings from 2010 aerial photographs of Addis Ababa. The selected informal settlement areas include the whole of Addis Ketema sub-city and Akaki Kaliti sub-city Kebele 07. The study also purposefully selected two formal settlement areas for object-level detection. The formal settlement areas selected were the expansion area of the Kolfe Keranyo sub-city Kebele 02 and the intermediate area of the Bole sub-city Kebele 11 intermediate formal area.

1.5. Significance of the study

The significance of the research is described as indicated below.

- 1) The research shows how to curb overall deprivations in livelihood capital assets for the poor and realize urban restructuring or informal settlement interventions based on ABS. The ABS shows its effectiveness by ultimately ensuring phase-wise asset accumulation and consolidation for the poor in informal settlements to alleviate poverty as well as realizing urban restructuring programs.
- 2) The research quantifies the extent and growth trends of informal settlements and estimate population size and density for monitoring the status of SDG 11 execution in Addis Ababa.
- 3) The research shows how deprived areas are related to environmentally sensitive areas and environmental health indicators through temporal trends and causal research design so that policymakers can further design strategies regarding the deprived areas and people located in environmentally sensitive and health-risky areas.
- 4) The research shows how to develop a theoretical justification for spatial inequality, polarization, and multiple deprivations considering the linkages and overlaps of indicators and components emanating from the inductive approach. The research also triangulates the inductive approach patterns with the deductive theoretical, empirical and SDG frameworks to arrive at sound conclusions and generalizations. The above approach will improve the research's external validity in different settings.
- 5) The overall polarization of poverty and spatial inequality in Addis Ababa city implicates the necessity for a compensatory area-based policy and targeted resources. The MDI tools, a tool for ensuring area-based targeted policy, can compensate large populations with overlaps of problems by trickling fiscal disbursement to the most unequal and deprived to meet SDG goal 10 on inequality and SDG 1.4. on social protection rather than a sector-based approach.
- 6) The MDI can be used by planners, policymakers, and multilateral and bilateral agencies. In addition to resource allocation for deprived people and areas, the MDI is also useful for exempting tax for deprived areas, working in partnership with the most deprived communities, realizing negotiated planning, and prioritizing urban restructuring or upgrading interventions.

- 7) The study shows how to differentiate formal (less deprived object) buildings from informal (deprived object) buildings by interpreting reflectance, texture, shape and contextual information using RF, which in turn provides useful bases for designing appropriate urban structuring interventions and estimating the cost of upgrading small area units, especially in neighborhood planning interventions.
- 8) The research shows how to derive the driving force or main factors explaining the multiple deprivations faced by the urban poor for policy interventions.

1.6. Research limitations

The postponed census for 2018 limited the comparability of the 2007 and 2018 censuses, using similar multiple deprivation indicators. In addition, the non-availability of similar census indicators constrains the forecast of the overall trends of future deprivation as the basis for designing a strategy for alleviating the future challenges of urbanization in the thesis. The census population size projection differs from the population estimate for 2020 based on world population grid data (100 by 100 meters). The limitation of the census is that it has not been conducted since 2018, and whatever data is obtained is based on a realistic projection of the census from the 2007 census base population. The world population grid data shows the estimated population distribution for 2020, based on the census as well as the spatial distribution of built-up and residential areas. Yet, the population estimate for world population gridded data for 2020 is underestimated in comparison to the census projection for Addis Ababa city.

There is high computation memory and time required for performing multi-resolution object-based classification for the whole city jurisdiction in personal computers. Thus, the performance of the classification of building morphology for deprived buildings is restricted to the four conveniently selected sample areas of the city. The state-of-the-art showed that slum identification has been conducted using RF due to the learning ability for impervious and permeable surface classification of spectral and textural properties (Guo et al., 2020). This study used RF object-based classification. Yet, performing object-based impervious and permeable classification for the whole of Addis Ababa city needs GPU memory, which cannot be handled by personal computers. The current state of the art also showed that CNN's deep learning algorithm is even better for the identification of informal buildings and settlements. The advantage of CNN includes very accurate image recognition and classification, and the tool does

not require human supervision for the task of identifying important features. Yet, the disadvantages of CNN are that it requires a lot of training data, is much slower, and fails to encode the position and orientation of objects (Kuffer et al., 2022; Abascal et al., 2022; Engati, 2023). The requirement of large training data sets for classification, personal computer memory constraints and the lack of server-based computers constrain the conducting of object-based RF or deep learning-based CNN classification for the whole of Addis Ababa city instead of the sample area.

1.7. Organization of the document

There are six chapters in the thesis. The first chapter begins with an introduction that includes a background, a statement of the problem, the general and specific objectives of the study, the scope of the study, the overall organization of the document, its significance, a definition of key concepts, the significance of the study, and research limitations. The second chapter deals with the theoretical review, conceptual review, state-of-the-art, methodological review, and research gaps. The third chapter deals with the study area, research design, data types, sources of data, sample design, method of data collection, method of data analysis, method of data presentation, validation, and reliability. The fourth chapter deals with results and discussions, and the fifth chapter wraps up the summary, conclusion, and recommendation for the overall study.

1.8. Definitions and terms of key concepts

Concentrated poverty: it is defined as the "spatial distribution of socio-economic deprivation," specifically focusing on the density of poor populations. It is commonly used in scholarship and policymaking for setting thresholds for extreme or high poverty areas (Murray, 2015).

Deprivation: it is defined as a lack of resources of all kinds and opportunities (Townsend, 1979; Southampton Data Observatory, 2020).

Different aspects of deprivations: The different aspects of deprivations in this study include deprivations from sustainable livelihood capital aspects, the non-monetary and monetary aspects of deprivations derived from multivariate analysis, and urban morphology-based deprivations.

Deprived and less-deprived area: in this study deprived area refers to an informal settlement area and less deprived area refers to a formal settlement area. The definition is based on own classification for the purpose of this research reviewing theoretical frameworks.

Inequality: it is the occurrence of an unfair distribution of opportunities and resources among members of a certain society that considers geographic variations (Koh, 2020).

Informal housing: in the context of Ethiopia, informal housing refers to housing those breaches building standards and regulations (Mahiteme, 2014).

Multiple Deprivation Index: it is a quantifiable indicator of deprivations computed by combining multiple deprivation indicators and dimensions refined with multivariate analysis into a composite index.

Poverty: it is a money-metric consumption-based measure that assesses whether an individual household can afford a basic basket of goods (typically food, housing, water, clothing, transport, etc.), which will be subject to adjustment to account for the higher cost of living in urban areas when measuring poverty (Baker & Schuler, 2004).

Slum area: it is an informal settlement lacking access to improved water, and sanitation facilities, a sufficient living area (not overcrowded), structural quality or durability of dwellings, and security of tenure (adapted based on UN-Habitat, 2003b). According to UN-Habitat III (2015), in addition to the conditions, slum dwellers lack public space and green areas, and are constantly exposed to eviction, disease, and violence.

Slums of despair: 'declining' neighborhoods, in which environmental conditions and domestic services are undergoing a process of degeneration. It also constitutes the poorest of the poor and the unskilled ones as compared with the slums of hope (Stoke, 1962).

Slum of hope: progressing settlements that are characterized by new, normally self-built structures, usually illegal (e.g., squatters), that are in or have recently been through a process of development, consolidation, and improvement. It is shown not to be a center of disease or crime when compared with a slum of despair. It provides opportunities for inexpensive self-made shelter and income-generating activities as compared with the slum of despair (Stoke, 1962).

Sub-groups: the sub-groups considered for this research were disaggregated HHs by income status, gender, tenure status, unemployment, and education status.

Urban morphology: it is the study of urban forms and of the agent and process responsible for their transformation over time. Urban form refers to the main physical element that structure and shape the city including street, squares (public space), street blocks, plots, and building, to name the most important (Oliveira, 2020).

Chapter Two: Literature Review

The chapter conceptualizes primarily the ontological and epistemological assumptions which provide bases for the philosophical thought for the research which in turn provide the framework for the theoretical and conceptual consideration for the research. Then, based on the underlying conceptual and theoretical framework which is the forerunner of epistemology, ontology, and philosophical thought; variables and operation definitions are derived and then the overall research methodological design, instrumentation and data collection are framed.

2.1. Epistemological and Ontological frameworks

The ontological assumptions give rise to epistemological assumptions. The epistemological assumptions give rise to methodological considerations, and these, in turn, give rise to issues of instrumentation and data collection (Hitchcock and Hughes, 2003). There is an interrelationship between the theoretical stance adopted by the researcher and the methodologies and methods used, as well as the researcher's view of epistemology. Ontology is the study of being, that is, the nature of existence and what constitutes reality" (Crotty, 1998). The different paradigms that range from constructivism to post-positivism and others are all represented in terms of ontology [nature of reality], epistemology [how we know what we know], and methodology [the process of the research] (Creswell, 2009). Ontology represents reality by breaking it down into concepts, relations, and rules (Agarwal, 2005). This study is conceived and written considering ontology, which assumes reality is composed of clearly formed entities and identifiable properties expressed through concepts, symbols, and words. For instance, this study developed variables from concepts for statistical analysis for testing hypothesis. In addition, the research uses the slum ontology concept, rules, and relations for identification of urban morphology-based deprivations to comprehend reality. This study followed a pragmatic approach, which is not committed to any one system of philosophy or reality. The research problem is the basic denominator for deriving research methodologies (Creswell, 2003).

This research shows a reductionist element in post-positivism. This is because the research reduces ideas into a small, discrete set of ideas to test, such as variables that constitute hypotheses and research questions, in line with Creswell (2003). The post-positivist movement also claimed that there is no absolute truth. Based on this fact, the methodology of the research

uses statistical testing, cause-effect relationships, and correlation, which assign probabilities, error tolerance, and unexplained explanatory variables, comprehending the fact that we can only approximate the truth. The research also reflects the deterministic philosophy that says causes probably determine effects or outcomes (Creswell, 2003; Creswell, 2009), which is because the research predicts outcomes from the cause.

The research also reflected constructivism epistemology. Accordingly, truth and meaning does not exist in some external world but are created by the subjects' interactions with the world (Creswell, 2009). Based on the framework of constructivism epistemology, the research reflected the advocacy/participatory worldview since the deprivation and inequality study is an action agenda to help marginalized groups such as gender, race, class, and so on (Neuman, 2000). The research investigated qualitatively, in addition to quantitatively, through interviews, the deprivations of livelihood capital assets by the poor and sub-groups, the functioning of capability by the poor, and the role of institutions in reaching the poor. The research is intertwined with an action agenda, as it suggests planning and policy solutions for the deprived poor and socially excluded groups. To sum up, instead of focusing on procedural consideration of assumptions and then methodological consideration, the primary focus is placed on the research problem that gave rise to the pluralistic approach of a pragmatic worldview to derive legitimate knowledge for the research. The pragmatic worldview of the research problem of this thesis traced a major portion of the post-positivist worldview originating from the objectivism epistemology position, mixed with portions of the advocacy worldview originating from the constructivism epistemology position.

2.2. Theoretical Review

2.2.1. Overview on earlier theory on poverty and inequality

The theoretical framework influences the overall research deductive framework and design. The Chicago schools explicitly deal with the pattern of socio-spatial segregation by relating social attributes and spatial patterns (Gizem and Fulin, 2013). Based on this theoretical model, the deprivation area is identified in the transitional zone. It is the zone where new incoming migrants (especially the poor) first concentrate before succeeding in other zones (Park and Burgess, 1925; Gizem and Fulin, 2013). Then, the advent of the Alonso-Muth-Mills model has not only put the Chicago schema of Burgess's concentric theory on a more rigorous footing by predicting

concentrated poverty and gentrification. The above model predicted how the poor would outbid the rich for central location by acquiring small plots of land at a higher price and accepting overcrowding as the price of location (UN-Habitat, 2003a). In Addis Ababa, the poor are concentrated near the CBD (in a transitional zone), fitting the framework of Burgess. The poor, located near the CBD, survive by renting beds for temporary and recent migrants to survive in the place, conforming to the Alonso-Muth-Mills model. In addition, Alonso's bid rent model claimed that the poorest houses, poor people, and substandard buildings are concentrated on the outskirts of the city because the inner city is not affordable for the poor (Shieh, 2003). The theoretical frameworks substantiate the relationship between the pattern of concentrated poverty and population in the context of the global North (Wilson, 1987; Sheih, 2003; Narvaez- et al., 2013). According to Wilson (1987), the suburbanization of urban jobs and the exodus of middle-class blacks to white neighborhoods caused the concentration of underclass black people in American cities (Sheih, 2003). Wilson (1987) also claimed that concentrated effect of urban neighborhood coincided with joblessness, female headed households and welfare dependency.

According to Wirth minority theory, the development of traditional spatial models was not as important in the segregation of diverse populations as social and cultural factors (Gizem and Fulin, 2013; Wendt, 1997) opposing the earlier spatial models. Lewis (1966) stated that poverty is a vicious behavioral cycle perpetuated through subcultural adaptation (poverty passed from parent to child). Lewis's view was greatly influenced by Park's theory regarding natural regions producing their own moral order like that of slums (Park, 1936). Lewis (1966) claimed that the culture of poverty may persist even after physical poverty has been eradicated, and thus it may be possible to develop strategies to combat it by studying the subculture. The Marxist theory states that "there is no point in advocating policies that deal with symptoms of inequality without altering the basic generating force-capitalism" (Richard, 1975). The Marxist view has been criticized by Gizem and Fulin (2013), who argue that social class is the only class considered and that the process of people choosing to distribute themselves within the same class based on ethnicity or income is poorly evaluated.

2.2.2. Urban planning theories and the implication on deprived areas

Different theoretical frameworks and models have argued deprivations based on slum model perspectives. Some of the authors, such as Stoke (1962), considered inner city slums "slums of despair" while periphery informal settlements were "slums of hope". In reverse, Eckstein (1990) justified the reversal of the spatial model, resulting in the characterization of squatter settlements as "slums of despair" and inner-city neighborhoods as "slums of hope". Turner's (1982) modernization theory mentioned that squatter settlements are better in socioeconomic status as compared with inner slums and are seen as a slum of hope for individuals to improve their life chances and invest in their future. Yet, Turner's (1976) mobility theory argued that "the inner city is the initial receptor area for poor recent or rural migrants, and subsequently, those with higher income move to the periphery." On the contrary, according to Elias (2008), in the Ethiopian context, inner slums are no longer transitory and temporary places, as dwellers are stable due to the extremely low rent of Kebele housing and the level of tenure security they enjoyed. The growth machine theory about urban land use planning regulation argues that poor neighborhoods are vulnerable to transformation because growth is the result of the usurpation of political control by unrepresentative land-based political elites (Logan, 1976). Yet, Vicki, Josiah, and Simon (2014) challenge the idea that cities reflect elements of the growth machine theory and the exclusionary zoning by home voters' theory. The growth machine theory is disadvantageous for the poor, as the poor residents have little political control and bargaining power and occupy land that could be put to more valuable uses. Home voters, on the other hand, are comprised of the wealthier and more educated, and their practice of exclusionary zoning increases the value of their backyard property while preventing the poor from leaving the inner-city slum and exacerbating poverty concentration (Logan, 1976; Vicki, Josiah, Simon, 2014).

From the viewpoint of sustainable intervention, the framework for urban planning discourses has helped to reduce issues with informal settlements, socio-spatial exclusion, and deprivation (Lewis, 1966; Abram, 1966; Turner, 1982; De Soto, 2001; Payne, Rakodi, Durand-Lasserve, 2009; Arroyo, 2013; Fontana, 2016). According to the theory of the culture of poverty, boosting the class consciousness of the poor is one way to leverage human capital and end the downward spiral of poverty. The main tactical move for effective anti-poverty programs is to work within a culture of poverty, which creates a vicious loop of poverty (Lewis, 1966). For Lewis, any investment in the redevelopment or upgrading of the urban poor is a waste. Abrams (1966)

impeached Lewis by arguing that it is not a waste to assist the poor and slum housing is a poor response to self-improvement (Fegue,2007). Abram promoted gradual self-help empowerment, partnership, and emphasized building social capital through community participation in planning, design, and self-construction for leveraging human capital (Abrams, 1966; Arroyo, 2013). According to Turner's modernization theory, social and physical capital work together synergistically to enable the underprivileged gradually increase their capacity for self-help. Government participation is essential for the gradual improvement and formalization of informal settlements by providing tenure security, sites, and services (Turner, 1982). According to Turner's (1982) modernization theory, helping the poor gradually modernize their physical assets from traditional ones, in turn, helps them fight poverty and deprivation. According to De Soto (2001), the poor would be able to enter the formal market and transcend poverty if they had used as collateral the once-frozen physical capital asset acquired through property rights and land titling. The poor currently participate in the informal market because they cannot afford formality (De Soto, 1989; De Soto, 2001; Fontana, 2016). For the impoverished to build livelihood capital assets, land titling is an essential livelihood strategy (Dani & Moser, 2008). Renters' impoverishment and property owners' market-based evictions are made worse by direct regularization and property improvements. Due to unexpected increases in property and rental values, the original owners are being evicted from the market by selling the property to the affluent (Payne et al., 2009). The above concept is pragmatic since many poor property owners sell their property after regularization, and the infrastructure improvement and property value rise will increase the price of rent for renters. In sum, poor awareness of the issues in informal settlements led us to tackle each facet of deprivation independently (ECE, 2008), and many earlier urban strategies did not consider all possible livelihood capital assets for designing poverty alleviation coupled with informal settlement interventions. The other factor that is an obstacle to asset accumulation and consolidation for the poor is the costly and intricate regulatory frameworks and procedures. According to local requirements and resources, planning norms and standards need to be relaxed to assist the underprivileged in improving housing and addressing deprivations (Payne, 2003).

2.2.3. Theory on sustainable livelihood capital assets, social exclusion, capability, and asset theory of social policy preference

The theory of sustainable livelihood capital assets informs research on poverty and deprivation. Poverty is considered the denial of access to those things that ensure a sustainable livelihood. The assets that are recognized within sustainable livelihood theory are summarized by McLeod (2001) as the following livelihood capitals: natural, environmental, physical, human, social, and financial. In addition, institutional knowledge and political capital are included. Sustainable livelihood also included an examination of vulnerability context [trend, shock, and stress] (Morse & McNamara, 2013). The framework for sustainable livelihoods liberates development practitioners from conventional methods frequently limited to identifying and resolving issues. It makes development activities process-oriented by considering context and relationships (Serrat, 2017).

A livelihood comprises the capabilities, assets (including both material and social resources), and activities required for a means of living (Serrat, 2017). Among the capitals of livelihood are financial, human, physical, social, and environmental. Income through the selling of labor, saving, and credit are all examples of financial capital. Human capital includes abilities to work, knowledge, access to education and training, and physical and mental well-being. Along with infrastructure and services that people may utilize, physical capital also includes homes that individuals use, own, and rent. Social capital is a set of shared beliefs that enables people to collaborate in a group to successfully accomplish a goal. In urban settings, natural capital is important in cases of river contamination and evictions brought on by urban agriculture (Sheilah et al., 2001; Farrington, Ramasut, Walker, 2002; UNDP, 2017).

The deprivation of sustainable livelihood assets means deprivation in the environment and in physical, human, social, and financial capital (Alam, 1989). According to Lasse (2011), the dimensions of poverty and assets are interrelated so that an improvement in one has a positive impact on the other. The deprivation of one livelihood capital asset also impacts the other livelihood capital assets. The sustainable livelihood theory is derived from people's capacity to make a living by surviving shock and stress and relying on their capabilities and assets. In other words, the concept implies that because the poor themselves know their situation and assets better, they must build on their assets and capacities and become involved in the design of

policies and projects for poverty reduction (Lasse, 2011; UNDP, 1997). Capability is thus a set of combinations of capability and functioning, reflecting the person's freedom to lead one type of life or another. Functioning is related to achievement and more directly related to living conditions (Stanford Encyclopedia of Philosophy, 2011). In line with capability theory, Sen argues that the correct approach to assessing how well people are doing is their ability to live a life that we have reason to value, not their wealth of resources or subjective wellbeing (CMI, 2020). Poverty is viewed as the deprivation of basic capabilities (being well-nourished, clothed, married, educated, travelling, and healthy) as well as taking part in the life of a community (Sen, 1995).

According to Iverson & Soskice (2001), in relation to assets, there is an asset theory of social policy preference. This theory claims that individuals who have made risky investment in skills will demand insurance against the possible future loss of income from those investments. Workers deriving most of their income from specific skills therefore have strong incentive to support social policies that protect them against such uncertainties. The debate on asset based policy and low income household in 1990's lead to a common framework for Asset based social policy. Asset Based Social Policy suggests that individuals, households and community wellbeing is stemming not only from financial or cash payment but also from accumulate livelihood asset to capitalize in life goals and to sustain long term economic stability and social protection (Sherraden & Rank, 2008).

Social exclusion theory involves the lack, or denial of resources, rights, goods, and services, as well as the inability to participate in the normal relationships and activities available to most people in a society. It affects both the quality of life of individuals and the equity and cohesion of society (Levitas, 2006; Levitas, Pantazis, Fahmy, Gordon, Liyod, and Patsios, 2007).

2.3. Conceptual Review

2.3.1. Concept of Deprivation and poverty

Although the terms "poverty" and "deprivation" are sometimes used interchangeably, there is a major difference between the two (David, Helen, Joanna, Elisabeth, and Chris, 2011). People can be said to be deprived if they lack the kinds of activities and facilities that are recognized or usual in the community to which they belong, as well as the sorts of diet, clothes, housing,

domestic amenities, fuel, environmental, educational, employment, and social situations" (Townsend, 1987; David et al., 2011). If someone does not have enough money to meet their necessities, they are in poverty (David et al., 2011). Local contexts or situations also contextualize deprivation (Cecilia, 2006). Gordon (1995) suggested that the poor are more vulnerable to other types of deprivation due to their lack of income, highlighting the significance of financial indicators of poverty for reinforcing poverty trap. According to Pacione (2001), the root causes of deprivation are economic and result from unemployment, poor earnings, and a decrease in welfare spending. The justification mentioned above confirmed that various types of deprivation are caused by economic issues. According to Baker and Schuler (2004), even though income-based poverty measurements gave information on unmet needs and where they were, objective poverty measures were unable to identify the root causes, severity, risk factors, and coping mechanisms of poverty. Martinez (2005) said that policymakers are now aware of how crucial it is to consider multiple deprivations, including household living conditions (financial and non-financial). According to the above concepts, it is preferable to rely on sustainable livelihood frameworks rather than relying only on income-based indicators to understand the origin and severity of deprivations.

The amount of aggregated or disaggregated analysis for research on deprivation or poverty is the other problem that needs conceptual lenses. Masud (2015) claims that the research at the disaggregation level provides answers to the problems of where the poor are located and what types of capital assets are most necessary for their means of subsistence. In order to combat urban poverty and socio-spatial exclusion in a specific city, disaggregated poverty research is more practical (Baker and Schuler, 2004). Individual cities have pressing needs to identify spatially disadvantaged areas, prioritize based on poverty, ascertain sub-group poverty variance, or assess whether programs are reaching the poorest using disaggregated research rather than aggregated statistics (Conning & Hall, 1992).

2.3.2. Concept of deprivation and social exclusion

Deprivation is defined as "a state of observable and demonstrable disadvantage, relative to the local community or the wider society or nation to which an individual, family, or group belongs" (Townsend, 1987; Cecilia, 2006). However, social exclusion places a greater emphasis on interpersonal problems and the restriction of access to the main social structures, such as a lack of social integration, insufficient social involvement, and a lack of power (Room, 1995). The deprivation concept is related to a broader scale denial of opportunities and inability to participate fully in society rather than resources (Hirschfield, 1989; Saunders, 1998). Thus, the deprivation concept overlapped with the social exclusion concept. The sub-groups (gender, age, household type, and employment status) varied in their access to resources, rights, goods, and services in line with a social-exclusion theoretical framework (Levitas, 2006). Thus, the study of sub-groups makes sense for investigating people who are disproportionately denied social integration, participation, and power. The domain of potential social exclusion includes resources such as material and economic resources, access to public and private services, and social resources. The domains of exclusion from participation include social, economic, political, and cultural. The third domain for exclusion is quality of life, such as health and wellbeing, living environment, crime, harm, and criminalization (Levitas et al., 2007).

2.3.3. Concept of vulnerability versus poverty and deprivations

When there is uncertainty about a person's, a family's, or a community's ability to thrive in the face of changes in their external environment, such situation is said to be vulnerable (Serrat, 2017). Most people consider poverty to be a sign of limited access to resources and employment prospects. Yet, poverty has other aspects of social positioning such as geographic location, age, gender, class, ethnicity, community structure, community decision-making, and political issues that determine poor people's vulnerability (Yodmani, 2001). According to Damas & Israt (2004), impoverished households perceive poverty as vulnerability due to their exposure to significant risk and lack of protection from severe deprivation, which results in social marginalization and ultimately economic marginalization.

According to the previous study, it is important to investigate the vulnerability components of poverty because they reveal differences in asset availability and control as well as subgroups' disproportionate susceptibility, both of which contribute to poverty traps. Hence, whereas vulnerability relates to a household's defenselessness or trouble coping with several threats, poverty is mainly focused on a lack of resources or money. According to Damas and Israt (2004), disaster vulnerability is greater among poorer countries and marginalized populations than among the wealthy, and this vulnerability is heightened locally because low household incomes are a hallmark of household vulnerability. According to UN-Habitat (2007), poverty is the most significant socioeconomic factor of vulnerability because it exposes the urban poor to vulnerable positions more frequently.

2.3.4. Concept of spatial inequality and deprivation

According to Koh (2020), inequality is the occurrence of an unfair distribution of opportunities and resources among members of a certain society that considers geographic variations. Discipline affects inequality differently. The unequal distribution of political power is emphasized by a political scientist. The distribution of wealth, income, or consumption is what economists refer to as inequality (Osberg, 2001). The emergence of distinct areas of urban deprivation over time is correlated with spatial inequality in metropolitan areas (Grant, 2010) substantiating how spatial deprivation triggers spatial inequality and polarization. We can analyze the spatial disparities in living standards if we have detailed information regarding the distribution of multitudes of deprivation problems. Researchers and decision-makers increasingly gather or create geographically disaggregated indicators that provide details about the spatial distribution of inequality and poverty within an area to show inequity (Deichmann, 1999). The socio-spatial dimensions of inequality are significant since it affects not just a single person but an entire geographic area with a sizable population, leading to uneven geography, as in degraded neighborhoods, slum areas, or historic centers (Martinez, 2005).

2.3.5. concepts of residential segregation, inequality, and concentrated poverty

The specific position of one social group in relation to another is understood as segregation" (Lucia & Machado, 2017). Contrarily, Greene (1991) characterized urban poverty concentration as the confinement of the poor to a subset of neighborhood locations that are not connected to the urban fabric, which induces segregation. The definitions of segregation and concentration of poverty, as stated above, also include spatial elements. According to Lojkine (1979), who took inspiration from Marxism, segregation is an expression of socioeconomic inequities in urban areas and represents unequal land, goods, and service appropriation.

According to the theory presented above, the role of the state influences the social organization and territorial inequality (Lucia & Machado, 2017). "The fundamental cause of geographical segregation is in the economic links and social interactions that people have with individuals of their reference group," added Pascal and Pierre (2013). According to a recent study, people prefer to live in neighborhoods with neighbors that share their income, class, ethnicity, and religion (Van Ham, Tammaru, and Janssen, 2018), which in turn leads to the residential segregation of different sub-groups. Urban segregation makes it more difficult to combat urban poverty by combining the negative consequences of material poverty with physical and social segregation (World Bank Group, 2008). Segregation's role as a catalyst for inequality was brought to policymakers' notice by the transgenerational neighborhood effect. The transgenerational neighborhood effects are justified because children who grew up in disadvantaged communities are likely to continue living there in poverty traps (Van Ham, Hedman, Manley, Coulter, & Osth, 2014; Hedman, Van Ham, 2021).

On the other hand, some scholars claimed that the type of urban planning initiatives only serves to exacerbate socio-spatial division. According to Mario & Sonia (2001), the extensive urban renewal effort in Santo Domingo accentuated spatial segregation. The widespread expulsion of residents causes habitat fragmentation for the remaining residents as multiple streets cut across the established neighborhoods, which serves to further entrench segregation. Concentrated poverty is defined as the "spatial distribution of socio-economic deprivation," specifically focusing on the density of poor populations (Murray, 2015). The World Bank Group (2008) concluded that "everything being equal, poverty concentration and the risk of social segregation are higher when high-poverty neighborhoods are highly contiguous to each other rather than

dispersed all over the city" based on research on urban poverty concentration in Ethiopia's neighborhood scale.

Another factor in the concentration of poverty is exclusionary zoning planning regulations, which prevent poor people from building the kind of home they can afford in wealthy areas (UN-Habitat, 2003b). According to this argument, imposing restrictive building standards in the inner-city slum of Addis Ababa fostered the concentration of poverty and residential segregation because the poor could not improve their property and not use it as collateral for asset accumulation.

2.16. Concept and indicators of multiple deprivations

According to numerous empirical studies, there are multiple indicators and dimensions that can be used to explain deprivation. Deprivation is defined as a lack of opportunities and resources of all kinds, whereas poverty is a lack of money to meet needs (Townsend, 1979; Southampton Data Observatory, 2020). The Townsend index is constructed based on material deprivation variables such as unemployment, lack of a car, lack of a dwelling, and HH overcrowding (Townsend, 1979). Income, employment, education, health and disability, crime, barriers to housing services, and deprivation of the living environment are the seven domains that make up the 2019 English deprivation index (McLennan et al., 2019). The Index of Multiple Deprivation's livelihood capital asset framework specifies four different categories of deprivations, including "social capital, human capital, financial capital, and physical capital (Baud et al., 2009). See figure 1 for a dimension and indicator of multiple deprivations based on livelihood capital asset frameworks. Numerous authors proposed financial and non-financial indicators for multiple deprivations.

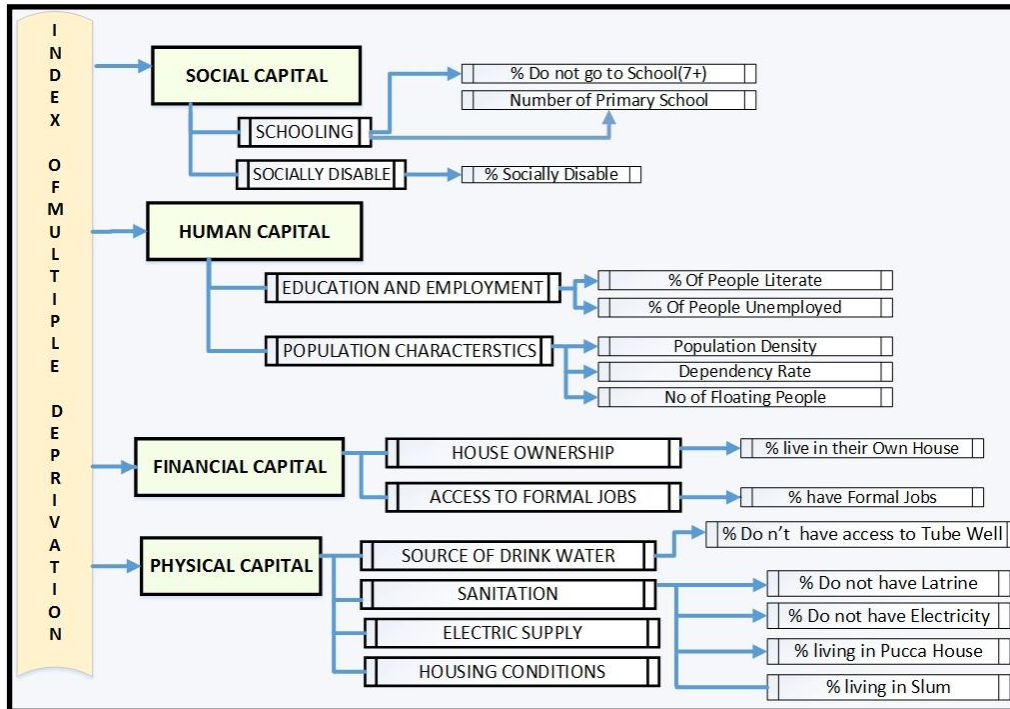


Figure 1 Variables and Indicators of Multiple Deprivation Index conceptualized by Masud (2015) based on Baud et al (2009)

Multiple deprivations include non-financial characteristics including overcrowding, inadequate water supply, poor sanitation, inadequate housing, limited access to education, insufficient rights protection, and powerlessness and voicelessness (Turkstra, 2004; Mitilin & Satterthwaite, 2004). Based on Martinez (2005), the MDI must take into consideration both the monetary and non-monetary aspects since the two dimensions measure various types of deprivation.

Other authors argued for social and economic vulnerability indicators for multiple deprivations. Economic vulnerability measures should be used since empirical investigation showed that the deprivation of economically vulnerable populations is multifaceted (Whelan & Maître, 2005). Social exclusion and indices of vulnerable groups, such as FHHs [female-headed households], age, and disability, are linked to deprivation (Berthoud, 1983; Wong, 2001; Yuan & Fulong, 2014; Qiu, Jianquan, Tianjie, 2022; Baud et al., 2010).

The spatial organization theory claimed that FHHs are particularly concentrated in the city's urban core. Thus, FHHs concentration indicates the spatial concentration of vulnerable and deprived groups (Wong, 2001). Moreover, morphological elements from remote sensing

imagery, such as building size, building density, and green or open space, are linked to deprivation areas (Baud et al., 2010; Ajami, Kuffer, Persello, Karin, 2019).

2.1.7. Concepts of physical deprivations: slum and informal settlement

Regardless of inequalities in economic levels, informal settlement refers to regions with a lack of security of tenure, inadequate service and infrastructure, and housing that doesn't comply with one or both planning and building laws. The slum, on the other hand, is a subgroup of an informal settlement that combines several unfavorable traits, including poverty, isolation, hazards, densification, a lack of green space, eviction, disease, and violence (UN-Habitat III, 2015). According to the ECE in 2008, an informal settlement is defined as housing that has been built without the legal title necessary for ownership and use of the land, housing that does not comply with planning and building permits, and housing that is vulnerable to marginalization and vulnerability. The term "informal settlement" refers to the occupation of land and houses that is either prohibited by traditional or customary law, allowed by such law, or otherwise justified by it (Geoffrey & Alain, 2012). Based on the above definition, the term extends from illegality to what would be legal and customarily recognized tenure, with the potential for recognition or ignorance by the legitimated official authority. Therefore, government recognition does not govern the definition of an informal settlement. The term informal settlement is used for a broad range of underdeveloped and illegal settlements formed on free land and occupied by low-income families without having permission from the land's rightful owners (Turner, 1969). The turner definition is more responsive for periphery underdeveloped informal settlements owned without requisition to legal title. Yet, in the case of Ethiopia, most inner slum houses have lawful Kebele ownership right while lacking other attributes such as building standard, infrastructure, services and feeling of tenure security.

Informal settlement is also identified by settlement stages. Slum has four stages of transient, provisional, incomplete & incipient, and complete (Turner, 1968; Sori, 2012). Recently, slums have been classified into three phases: infancy, consolidation, and saturation based on the availability of open space in the neighborhood (Abebe, 2011; Sori, 2012). Other authors considered Illegal construction characterizes informal settlement as a continuous process of change (Samper, Shelby, Behray, 2020). The continuous process of change is shared in an

Ethiopian context by Tarekegn (2000), who claims that there is continuous illegal construction, or "kitya houses," in the inner-city slum.

Informal housing in the context of Ethiopia is defined as housing that does not adhere to legally enforceable building norms and regulations. In Ethiopia, the term "formal housing" refers to properties owned by individuals, businesses, and the government that adhere to all applicable regulations, including those governing land leases and construction rules (Mahiteme 2014). Since Addis Ababa has standard housing on illegally occupied land but may not have de jure tenure right, the Mahiteme (2014) definition is appropriate. The operational definition of a slum agreed upon by different countries is in line with SDG 11.1.1. A slum is a household lacking access to improved water, improved sanitation, a sufficient living area, durable housing, and tenure security (UN-Habitat and Global Urban Observatory, 2019).

2.1.8. Concept of slum ontology as basis for urban morphology based deprivations

The ontology concepts are represented at three levels: environment, settlement, and object levels. The six general indicators that represent the ontology concept form a hierarchy at the levels of environment, settlement, and object. Environmental levels are concerned with location and neighborhood characteristics (see figure 2).

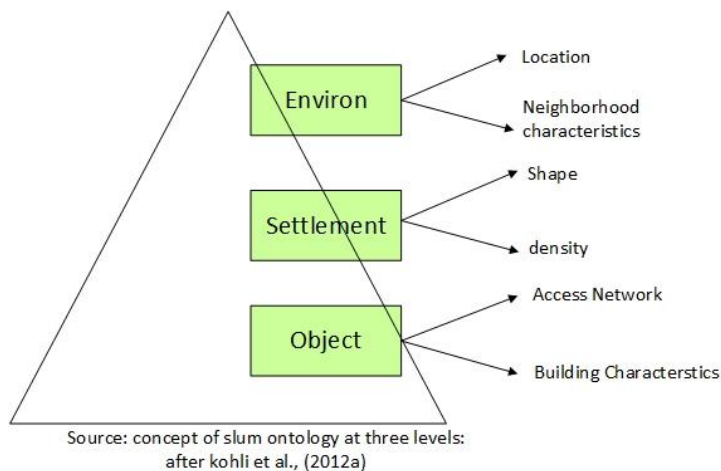


Figure 2 Concept of slum ontology at three levels

Settlements are concerned with shape (building, settlement, and road) and density. The object level is concerned with building characteristics and access networks (Kohli et al., 2012a). The object level comprises building characteristics observable via VHR images, such as roof material, footprint, shape, and orientation, the regular and irregular structure of the road, and the type and width of the road. Environ consists of the area surrounding the settlement, i.e., its location with respect to neighboring land uses, or areas with specific environmental conditions, such as hazardous areas. The settlement level consists of the overall form, shape, and density of the settlement (Kohli et al., 2012a; Kohli, Kerle, and Sliuzas, 2012b). Regarding object level, the footprints of dwellings in slums are smaller than those of planned settlements. At the building level, based on Kisumu in Kenya, roofs are overlapping for different dwellings and are generally less bright than in formal settlements. The colors of roofs are generally gray, dark brown, or bluish gray in color (Kohli et al., 2012b).

Regarding settlement level, a slum settlement generally has an irregular access network with variable street types, surfaces, and widths. At the settlement level, the slum has generally high roof coverage with no open space or vegetation (Kohli et al., 2012a; Kohli et al., 2012b). At the environmental level, based on the Kisumu, Kenya, experience, slums can be identified in flood zones, marshy areas, close to farmland, close to the CBD, and along highways (Kohli et al., 2012b).

2.4. State-of-the-art

The state of art has three major parts. The first part reviews the literature regarding the interrelationships between sustainable livelihood, capital asset deprivations, and asset-based social policy. The second part reviews the literature pertaining to the spatial pattern of deprivations and inequalities and their policy implications. The third part reviews literature related to the pattern of deprivations from the perspective of urban morphology.

2.4.1. The sustainable livelihood capital assets deprivations and their implications for asset based social policy (ABS)

The discourse of urban planning indicated that past frameworks did not thoroughly explore the range of livelihood capital assets in poverty and informal settlement interventions. They only addressed one or more aspects of sustainable livelihood capital asset deprivation (ECE, 2008).

Designing strategies and policies for informal settlement reduction and housing interventions that consider the poor's access to livelihood capital, assets, and rights is a requirement of the inclusive, integrated, and resilient approach (Soma et al., 2020; UN-Habitat, 2020a; Wang et al., 2021a). The lack of effective governance and regulatory frameworks exacerbates the issues faced by urban poor people, limits the significant potential for human development offered by urban life, and precludes the attainment of sustainable livelihoods (Majale, 2002). Currently, the overall improvement of livelihood capital assets is integrated into the planning of interventions. With the new urban agenda of leaving no one behind (informal and formal), as well as the integrated attainment of SDG 11 and SDG 1, the present Caribbean upgrade of informal settlements took a comprehensive, integrated, and resilient strategy (UN-Habitat., 2020b). Due to the adoption of the framework for livelihood capital assets, rural land consolidation in China increased initial livelihood capital endowment, decreased vulnerability, and increased livelihood capital accumulations (Wang et al., 2021a). The current study discovered a connection between housing conditions and capital assets for livelihood in an urban slum in Dhaka, Bangladesh (Soma et al., 2020).

In countries of sub-Saharan Africa (excluding South Africa), the average, men's, and women's informal employment accounts for 92%, 89%, and 95%, respectively (Florence, Vanek, and Chen, 2019). The great majority of individuals rely on the limited assets they are endowed with and accumulate through the informal economy since there are few practical opportunities for employment in the formal sector. Since most poor people in informal settlements do not rely on salaried employment, their capacity to acquire and accumulate assets, generate an adequate return from these assets, and use the asset base to manage risks is essential to their livelihoods and well-being (Moser & Dani, 2008). The cornerstone to lowering risk and vulnerabilities is asset mobilization (Vatsa, 2004). Like the previous point, regulatory frameworks in Ethiopia are not created to fully exploit the control and access of the poor to sustainable livelihood capital assets (Lakisha, 2012; MFA, 2005; MUDHC, 2003; UN-Habitat, 2011; Kloosterboer, 2019). Ethiopia's urban development plan promotes the construction of housing estates for low-income populations with long-term loans (Ministry of Federal Affairs, 2005). Yet, IHDP (Integrated Housing Development Program) interventions reveal that 70% of Addis Ababa's 175,000 condominium unit residents reside in informal settlements after renting out their homes to middle- and high-income groups (Lakisha, 2012). The circumstance shows that before creating a significant IHDP, it is important to consider the poor's livelihoods, including their economic

potential, social connections, and financial capital. Urban renewal policies in Addis Ababa destroyed prospects for economic growth and social cohesion for existing dwellers (UN-Habitat, 2011). Due to inner-city renovation, at least 28,584 HHs (households) in Addis Ababa were relocated between 2009 and 2016 (Kloosterboer, 2019). The government created an urban development strategy in 2007 with a focus on housing, infrastructure, job growth, and a good governance package (UN-Habitat, 2014). The above policy produced incredible results in terms of job creation and IHDP homeownership, but it was inconsiderate to the chronically poor's livelihoods (Kassahun & Tiwari, 2012). The land management regulation uses coercive bulldozing to stop the growth of new unauthorized settlements while enforcing a timeframe of systematic regularizations for Ethiopian cities (MUDHC, 2003). As a result, the legal enforcement agency continued to demolish newly constructed illegal residences, depriving the impoverished in Addis Ababa's peri-urban settlements of their right to possess a home (physical capital). Yet, the expansion of informal settlements is still going on today (T. Getu, personal communication, October 29, 2021). There is a sizable unemployed population in Ethiopia and the unemployment rate in Addis Ababa reached 23.5 percent, despite the employment strategy of Ethiopia calls for the creation of jobs through sectors (public and private), self-employment, and entrepreneurship (World Bank Group and Cities Alliance, 2015). The 10-year development plan (2021-2030) now acknowledges the use of capital assets for livelihood for prosperity and growth (PDC [Planning and Development Commission of Ethiopia], 2020). Yet, the 10-year plan also requires evaluation in terms of how interventions in informal settlements that strengthen livelihood capital assets are done.

Now, one of the keys 21st-century driving forces is sustainable urbanization (UNDG, 2012). Yet, the complexity of the rise of informal settlements and the increased level of social, economic, and spatial exclusion poses the biggest obstacles to sustainable urbanization (Jones, 2017). The livelihood capital that HHs possesses helps to build strategies to accomplish livelihood goals including income, shelter, security, and general welfare (Ding, Jimoh, Hou, Hou, & Zhang, 2018). The literature advocated the interrelationships of the livelihood capital assets to livelihood strategies for reducing poverty and promoting sustainable urbanization (Sheilah et al., 2001; Farrington et al., 2002; Baud et al., 2009; UNDP, 2017; SDG Tracker, 2019; Wang et al., 2021b). For instance, capable human capital is a key determinant of financial capital in terms of earnings and access to jobs. By the relationship between home quality and health as well as a mutual support system for constructing a house through social capital, physical capital is a

crucial factor in determining human and social capital (Farrington et al., 2002). Equal access to resources and public goods, as well as the effectiveness of economic and social interactions, are all enhanced by social capital (UNDP, 2017). Lack of clean water, inadequate sanitation, and inadequate housing all contribute to poor health, which makes it difficult for people to work efficiently and decreases their capacity to generate money (Baud et al., 2009). The opportunity cost of inadequate infrastructure impedes access to healthcare, education, and employment (UNDP, 2017). Financial capital is a significant asset to develop and cumulate other assets and support livelihood activities (Wang et al., 2021b). Recognizing the above relation, SDG argued the achievement of livelihood strategies in integrated manner. SDG-11 argued about the link between SDG poverty goal 1 and goal 11 of access to land, slums, and inadequate housing (SDG Tracker, 2019) since livelihood capital assets are interrelated. The preceding framework indicated the interrelationships among deprivations of sustainable livelihood capital assets and the relevance of emanating strategic issues for addressing deprivations from sustainable urbanization perspectives coupled with other components of livelihood strategy review—the capability and institutional aspects.

The livelihood-capital asset interrelationships implicate the crucial role of asset accumulation, which is pragmatic through the functioning of capability. The capability approach focuses on what people can be and do with the resources and goods (Robeyns & Morten, 2021). The creation of capabilities strongly depends on the set of capital assets available. The greater the erosion of people's assets, the greater the vulnerability and insecurity (Lienert & Burger, 2015). Individuals and communities are crucial to the expansion of capabilities (Graciela, 2018). Hence, transitioned from focusing on money and consumption to emphasizing the crucial role that assets and capacities play in enhancing well-being (Moser, 2008). The first generation of ABS gives people and HHs the tools they need to independently continue to build up their wealth for a living and eventually escape poverty. The first-generation emphasizes on provision of social and economic infrastructure (water, electricity, road, housing plot, better health, and education). When the above strategies do not bring the expected development proceeds and increased human capital it leads to violence, alienation, and social exclusion (Dani & Moser, 2008). Moreover, in line with asset theory of social preference, individuals who have made risky investment in skills will demand insurance against the possible future loss of income from those investments (Iverson & Soskice 2001). In such a case, the second generation is concerned with protection of the first-generation asset from erosion by interventions in improving governance, accountability,

social justice, social security, orchestrating appropriate institutional structure, and citizen's information right (Caroline & Moser, 2006). The steps of asset accession, valuation, and transformation are how the ABS accrues assets (Dani & Moser, 2008; Moser, 2008), which implies addressing deprivations and poverty. Asset accession aims to improve the ability of the underprivileged to bolster the asset base. Lowering the unaffordable price, establishing tenure security, recognizing individual and collective rights, and focusing on disadvantaged women and subgroups are some of the methods for asset accession. Public investment is the main emphasis of asset valorization to boost returns or asset value. Investments in human capital, public goods and infrastructure, business skills, and the organization of the poor are a few examples of investments that are valued. Asset transformation places an emphasis on transformative public policy and securing a stable income by removing obstacles. For instance, in slums, acknowledging the function of housing federations as organizations that serve as mediators for the rights of the poor, legitimizing individual rights and collective assets, and removing institutional and legal obstacles that hamper the poor's ability to engage in economic activity (Dani & Moser, 2008).

Ethiopia implemented UPSNP in 2016 to promote asset accumulation by providing security for the urban community and enhancing income and employment opportunities in public works (Gebreselassie, 2019; Abiy, 2020). UPSNP is a comprehensive and inclusive social program that aims to reduce poverty among the urban poor living below the poverty line. The beneficiaries were selected at the 'Ketena' level based on lower educational attainment, lower asset ownership, and living in overcrowded rooms (World Bank, 2017). The UPSNP review of Mekele City indicated UPSNP increased beneficiaries' income, reduced threats to their livelihoods, and improved food security (Gebresilassie, 2019). As of September 2020, UPSNP reached 600,000 beneficiaries, execute livelihood grants to 51000 beneficiaries to commence small businesses (after financial literacy and training), upgrade neighborhood quality, and connecting 60, 000 people to health insurance, education, and housing support (World Bank Group, 2021)

By enhancing the capabilities of the poor and encouraging self-employment, MSSE is an institutional asset for reducing poverty and creating jobs. MSSE is the strategy of GTP II to generate employment and reduce poverty with an emphasis on youth and women (Endris & Kassegn, 2022). Yet, MSSEs have been hampered by the issues with revolving fund recovery for conventional collateral-based lending. As a result, to ensure the success of MSSE and the

increase of capital asset accumulation, it is pertinent to implement asset-based lending and special funding for MSSE (Nega & Edris, 2016).

Considering social exclusion theory, access to resources, rights, goods, and services differed by subgroups: gender, age, home type, and work position (Levitas, 2006). Based only on an analysis of income, Jayamohan and Amenu's (2014) research claimed that the feminization of poverty is a tenuous claim in urban Ethiopia—without relating gender to deprivations of sustainable livelihood capital assets. In 2014, youths finishing secondary and post-secondary education made up half of the jobless Addis Ababa population (FDRE, 2018). The above result implicates interventions for orchestrating curriculum and competencies to fit job opportunities. The vulnerability of the subgroups of elderly slum dwellers was highlighted by Aboderin et al. (2017). The inner-city slum of Addis Ababa consists of a high percentage of the old population, which lacks access to and control over sustainable livelihood capital assets. These groups require old-age slum mainstreaming activities, like gender mainstreaming. Like the sub-group variances, people's capacities also differed in what they could achieve and be with those resources (Robeyns & Morten, 2021).

Moreover, by regulating and affecting how, when, and by whom they are used, institutions have an impact on the spectrum of livelihood capital access and control (Messer & Townsley, 2003). In other words, an institution can make a difference regarding subgroups' access to and control over livelihood capital used to support their way of life. The institution consists of formal, informal, political, economic, and sociocultural organizations (Carloni & Crowley, 2005). Access to capital for livelihood has been modified through institutional structure, policy, legislation, and procedure (Carloni & Crowley, 2005; Serrat, 2017). Hence, pro-poor public policies must concentrate on developing institutional frameworks that let poor and vulnerable individuals build and earn a return on their assets (Dani & Moser, 2008). Local institutions help build social capital, which, in turn, makes it easier for vulnerable subgroups to access finance for their livelihoods (UNDP, 2017). Based on a South Asian study, poverty was made worse by the lack of access to enabling institutional support for accumulating assets (Shahbaz et al., 2010). Inadequate institutional capacity impairs social networks' ability to acquire financing and employment, which in turn has a negative impact on vulnerable subgroups (Bebbington, n.d.).

The research conducted in Urban Ethiopia argued on the relevance of sustainable livelihood capital assets frameworks for livelihood impact assessment, curbing poverty, food security and

livelihood options of migrations. Yirga (2001) argued many poverty and food security-related research overlooked urban settings and the Sustainable Livelihood Capital Asset framework based on Gondar city, Ethiopia. Migration is a livelihood option for Wolayita Sodo caused mainly due to poverty and unemployment (Amphune, Weldegebiel, & Enaro, 2018). The current research investigated urban expansion impact on livelihood in Burayu city, Ethiopia (Talema, 2023).

2.4.2. Deprivations and socio-spatial inequality policy and monitoring tools review

2.4.2.1. People and area-based policy

The advantages and disadvantages of policies based on people or place are open to debate. Place-based policies have a specific area focus and are designed to aid their disadvantaged population. People-based policies assist those who are in need without considering their location or level of disadvantage (Neumark & Simpson, 2014). When deciding whether to adopt a place-based or people-based policy, the program's goal is crucial. The location could aid policymakers in identifying the intended beneficiaries, if the concentration of poverty is particularly prominent (for example, in the metropolitan core). Enterprise zone programs that seek to create jobs in or near areas where people live, and the job prospects are weak (Neumark and Helen, 2014). But if the objective is to increase accessibility to affordable housing, a people-based program of housing vouchers is less wasteful and more focused (Crane and Manville, 2008). According to the 2009 World Bank report, governments should prioritize economic concentration and people-based policies by offering universal welfare benefits for underdeveloped areas at an early stage of development. Yet, it is advised to use spatial targeting in nations with high rates of urbanization, divided cities, significant regional differences, and small economies that are cut off from the global market (Turok, 2013).

Area-based approaches provide numerous advantages from a variety of angles (Turok, 2013; Tunstall, Lupton, 2003; Crane & Manville, 2008; Smith, 1999; Hohmann, 2014; Sabine, Ali, Peter; 2021). The area-based approach makes sense for compensating regions with concurrent and overlapping problems, lessening geographical inequality, and reaching substantial, underprivileged populations who suffer disproportionately (Smith, 1999). Area-based policies

can provide a framework for community planning and development, reduce residential segregation, promote social and spatial justice, and reach some disadvantaged subgroups (Turok, 2013; Tunstall and Lupton, 2003; Hohmann, 2014; Sabine et al., 2021). Concentrated poverty typically involves more challenges than a lack of personal resources. Good education and crime reduction are examples of public goods that have favorable neighborhood and social network effects on reducing poverty (Crane & Manville, 2008). In England and Germany, neighborhood-based projects in deteriorating urban areas encourage people's active participation in the voluntary sector (Hohmann, 2014).

Moreover, area-based targeting has been used in SSA, particularly in the experience of urban planning in rapidly expanding cities and agglomeration economies (Wahba & Ranarifidy, 2018; Tesfay, 2016). Kinshasa, a metropolis with rapid urban growth and agglomeration economies, has planned institutional and infrastructure upgrades, as well as priority regions that are geographically targeted (Wahba & Ranarifidy, 2018). Based on the criterion that an area should be targeted as an "upgrading area" in the statutory plan if a significant fraction of its housing lacks drainage and sanitary infrastructure, Addis Ababa launched area-based targeting for prioritizing urban upgrading (Tefsay, 2016), despite no empirical tools being developed.

2.4.2.2.MDI tools and area-based policy

In place of the population- and other criteria sector-based budget allocation and uniform transfer budgeting, policymakers have employed MDI techniques to realize area-based or geographically targeted policies. The area-based policy will boost the effectiveness of allocating resources for reducing poverty and minimizing leakage to the non-poor (Bigman & Fofack; 2019). By creating an MDI, the area-based policy is realistic. The MDI is a method for allocating resources for eradicating poverty and regenerating urban areas. It is a relative assessment of multiple deprivations at a small-area level (McLennan, n.d.). Different countries have explored the MDI in different contexts by employing different methodologies and techniques for different applications (Coombes and Raybould, 1989; Andrea, 2012; Deas et al. 2003; McLennan et al., 2019; Glassman, 2019; UN-Habitat, 2020c; Noble, Babita, Barnes, Dibben, Magasela, Noble, Ntshongwana, Phillips, Rama, Roberts, 2006; Patel, Shah, Beauregard, 2020). In collaboration with the community, the Welsh government has employed the MDI for urban revitalization (Coombes and Raybould, 1989; Andrea, 2012). Since 1990, England has used the MDI to

disburse renewal money, boost the housing market, and offer tax exemptions (Deas et al., 2003). The English MDI employed factor analysis to integrate indicators and give weight to components (McLennan et al., 2019). The Alkire Foster approach was employed in the USA to determine who is poor by recording and studying the various forms of deprivation people encounter, then calculating a multidimensional poverty index [MPI] (Glassman, 2019). The SSA secondary cities' poverty alleviation program was created by UN-Habitat using a variety of deprivation indices (UN-Habitat, 2020c). Using the MDI, which was created based on PCA, South Africa prioritized the delivery of social services to underserved communities (Noble et al., 2006). The India Slum Severity Index is used to evaluate the severity and extent of housing problems and identify the most impoverished slum dwellers (Patel et al., 2020).

Budget allocation structures that disproportionately benefit impoverished people, disadvantaged women, and vulnerable groups are required under SDG 1 (SDG, 2018). Thus, area-based techniques adopting MDI support a people-based strategy for giving vulnerable groups priority in situations of poverty polarization and fund shortages to achieve SDG 1. In accordance with SDG objective 1.3, the MDI is effective in identifying vulnerable individuals who need social protection payments, such as elderly individuals, disabled individuals, mothers, and jobless individuals (World Bank, 2022). In accordance with SDG 1 goal 1.4, the MDI prioritizes by geographic area the poor and vulnerable individuals who need access to resources and services (SDG, 2018).

In conclusion, the MDI is an essential tool for identifying and prioritizing disadvantaged and vulnerable groups, putting anti-poverty programs into action, and locating areas with fewer opportunities and resources. It is also useful for allocating resources effectively, revitalizing urban areas, encouraging community partnership and participation, providing preventive health services, and assessing housing extent and problems. The MDI has some drawbacks, including the inability to account for disadvantaged populations residing in non-poor areas, a reduced utility for rural areas due to dispersed spatial patterns, and a lengthy construction process for trend data on a significant number of MDI variables. Several nations have begun to employ the MDI as a tool for policymaking; nevertheless, future attention must be paid to how to interpret and convert indicators into policy decisions (Clelland and Hill, 2019). The SSA, where poverty polarization is widespread, has minimal experience investigating the MDI for a variety of applications, except for a few nations in southern Africa.

2.4.2.3 The existing situations of deprivations and socio-economic inequality

If people are not given access to opportunities, services, and a better life, development will not be sustainable. To achieve SDG 10, disparities in income, age, sex, disability, race, and ethnicity must be reduced (UNDESA and World Bank Group, 2019). Due to concentrated poverty, SSA, especially Ethiopia, has seen no improvement in recent years in the Gini coefficient measure of spatial inequality (Shifa and Leibbrandt, 2021). With more disparity in urban than rural areas, Ethiopia's urban inequality increased slightly from 0.29 in 1995 to 0.37 in 2010–11 and 0.38 in 2015–16 (Debebe and Zekarias, 2020; MOFED [Ministry of Finance and Economic Development], 2013). Recently, Ethiopian cities are facing a growing income disparity, with the bottom 10% of the population receiving only 4% of the nation's total revenue (Wolde, Sera, Merra, 2022). More income inequality is caused by growing urbanization because migrants from rural areas are attracted to higher-GDP cities (Sulemana, Nketiah-Amponsah, Codjoe, Akua, and Andoh, 2019). This is especially true in the case of Addis Ababa, where rural-urban migration drives the city's urbanization and migrants constitute 42% of its population (Bundervoet, 2018; CSA [Central Statistics Agency of Ethiopia], 2021). Irrespective of the ongoing inequality, the Addis Ababa headcount poverty index decreased significantly from 28.1% in 2010/11 to 16.8% in 2015–16 (ENPC, 2017; MOFED, 2013). The Ministry of Urban Development and Housing (MUDH), 2015; World Bank Group and Cities Alliance, 2015) forecasts that Ethiopia's level of urbanization, which was 21.2 percent in 2019 (Koroso, Lengoiboni, Zevenbergen, 2021), will rise to 37 percent in 2035. This assumes that the nation's urban growth rate is 5.4 percent per year.

Urbanization in Ethiopia has not been correlated with a corresponding rise in economic prosperity. For instance, in Addis Ababa, 23.5 percent of households (HHs) recently reported having individuals with no employment (World Bank Group and Cities Alliance, 2015). Ethiopia must address the problems caused by rapid urbanization, including deepening poverty, high unemployment rates, the rapid growth of squalid conditions, a severe housing shortage, and a rising risk of environmental hazards, to achieve middle-income status (MUDH, 2015). In Ethiopia, pro-poor expenditures contributed to 65.7% of all public spending in 2015–16 (ENPC, 2017). However, the decline in non-financial welfare (health, education, sanitization, and water access) was minimal (World Bank Group, 2020a). Ethiopia should achieve SDG target 1.2, which calls for cutting in half the percentage of people of all ages who live in poverty in all its

forms (SDG Tracker, 2019). The MDI, which considers and weighs a broad range of problems, can be used to link, and monitor SDGs. SDG 1 on poverty, SDG 8 on employment, and SDG 4 on education are all related. The relationships are substantiated because education lowers poverty by raising individual incomes and enhancing worker productivity. Apart from the relationship between SDG 4 on education and SDG 11 on disaster management, there is less evidence connecting urban development (SDG 11) and education (SDG 4). (Vladimirova and Le Blanc, 2015).

2.4.3. Urban morphology based deprivations: analysis levels and local perspectives

2.4.3.1. Sustainable urbanization challenges and the growth, trends and characteristics of deprived areas

The challenges to sustainable urbanization policy are the growth of informal settlements and poverty (Jones 2017; Liddle 2017), which combine to create ultimately multidimensional deprivations. World urbanization surpassed 50% in 2009 (Liddle, 2017) and 54% in 2015 (UN-Habitat, 2016). The absolute number of poor people in developing countries increased from 689 million in 1990 to 807 million in 2000, 881 million in 2014, and 883 million in 2015 (UN-Habitat, 2016; SDG, 2018; UNICEF and UN-Habitat, 2020). A significant proportion of the poor live in rapidly urbanized areas (SDG, 2018). Studies indicated that between 1990 and 2014, the proportion of the population living in slums decreased from 46 percent to 23 percent. Yet, many developing countries experienced rapid urbanization (UN-Habitat and Global Urban Observatory 2019), which increased the absolute number of poor people. According to studies, a 1% increase in urbanization leads to a 2.3 percent increase in slum incidence in Africa (United Nations, 2023b). The SDG for target 11.1.1's focus area is to comprehend the percentage of the population living in slums or informal settlements to realize managed urbanization and adequate living conditions (United Nations, 2023a). Since the past couple of decades, regional cities in Ethiopia have grown faster than the capital city, Addis Ababa (UN-Habitat, 2017). The Oromia Special Zone surrounding Addis Ababa is one of the most rapidly growing towns in Ethiopia (Terfa, Chen, Zhang, Niyogi; 2020), which consists small and medium sized cities.

Poverty is increasingly urbanized and expressed by high living costs, limited services, and social marginalization (UNDG, 2012). Properly planned and managed urbanization contributes to a reduction in poverty, otherwise poverty and inequality will remain an enduring feature of urban future (UN-Habitat, 2022). Unplanned rapid urbanization is associated with the proliferation of deprived areas (slums and informal settlements) in low and middle-income countries, and planned urbanization lead to poverty reduction (Tjia & Coetzee, 2022). However, the urbanization of poverty, combined with unequal resource distribution and anti-poor policies, leads to rising urban poverty (UNDG, 2012). In 2035, most of the world's extremely poor will live in urban areas. Therefore, urban centers have become the focal point of multidimensional poverty (UNDP 2016). Ethiopia is no exception to multidimensional poverty prevalence in urban areas, aggravated by the high annual urbanization rate of 5.4% (World Bank Group and Cities Alliance, 2015) and the trends of urbanization of poverty. The unavailability of the census since 2007 has made the population estimate unreliable with different projection rates. The projected population sizes for 2010 and 2020 were 2,912,000 and 3,689,000, respectively (CSA, 2013a), giving a 2.67% annual population growth rate. The annual population growth rate of Addis Ababa is estimated at 3.8 percent (World Bank Group and Cities Alliance, 2015). Based on SDG 11, there is a growing interest in the proportion of the population living in deprived areas (UN-Habitat and Global Urban Observatory, 2019). In addition to the rampant inner-city slum, the size and number of informal settlements have increased currently on the edge of many urban areas of Ethiopia (Hamza, 2023). Yet, in Addis Ababa, Ethiopia, the informal and formal settlement populations, and areas have not been clearly known yet. Different countries estimated the population living in deprived and less deprived areas based on gridded population data. In Lagos, Nigeria, all gridded population datasets underestimated the SDG 11.1.1. indicator of the population living in deprived areas at just 1–3 percent (Thomson, Gaughan, Stevens, Yetman, and Elias; 2021). Despite the underestimation problem of the gridded population data of the WorldPop (2010 and 2020), it is possible to estimate the proportion of population living in informal settlements once the informal settlement area is known.

Sustainable urbanization has become one of the global transformative drivers of the 21st century. Sustainable urbanization requires averting the challenge faced by cities through structural transformation and interventions (McCormick et al., 2012). The structural transformation, for instance, upgrading informal settlements, requires consistent, detailed, and accurate geospatial

information on deprived areas (Tjia & Coetzee, 2022). For monitoring informal settlements, SDG uses geospatial technology for slum identification (SDG, 2018) by interpreting morphological structures extracted from high-resolution (VHR) images and validating the facts with ground verification and other statistical information. The deprivation area map is the basis for estimating the progress towards SDG 11 regarding the proportion of people living in slums and informal settlements (Kuffer et al., 2020).

SDG target 11.7 calls for vulnerable groups (women, children, the elderly, and people with disabilities) to have access to green and public places (SDG, 2018). As a result, monitoring SDG target 11.7 requires an integrated analysis of morphology-based deprivations and social and economic vulnerability. In Ethiopia, along with urban and settlement types, deprivation varied. The inner-city slum of Addis Ababa is characterized by signs of deprived green or open space, outdated buildings, vulnerable communities, an overcrowded population, degenerating infrastructure, and deteriorating housing conditions (UN-Habitat, 2017; Elias, 2008; Habitat for Humanity Great Britain, 2017; UN-Habitat, 2017). However, Addis Ababa's peri-urban informal settlements, which consist of poor, vulnerable rural-urban migrants who acquired land through the transaction of agricultural land; thus, a lack of tenure rights and a lack of infrastructure distinguish peri-urban informal settlements (Bundervoet, 2018; Elias, 2008; Berhanu, Woldemikael, and Beyene; 2022).

Tenure rights, improved water and sanitation, housing durability, and enough living space are among the SDG 11 housing inadequacy indicators that have been outlined so that nations can track their progress in achieving the intended goals and targets (SDG Tracker; 2019). In Ethiopian urban centers, there are three urban forms: the peri-urban informal settlements, declining inner cities, and planned new development areas (Tesfaye, 2019). This, in turn, reflected the link between urban form indicators and disadvantaged areas. In the case of Ethiopia, informal housing refers to housing that does not comply with the legally enforced building standards and regulations (Mahiteme 2014), regardless of tenure legality. The old possession right in Ethiopia has legal recognition like the lease right as per Registration Proclamation No. 818/2014, Article 2 (FDRE, 2014). Yet, most old possessions (permit rights and Kebele/municipal rent) consisted of substandard and dilapidated houses that did not comply with planning and building standards and regulations. The old possession houses consisted of Kebele, and municipal houses confiscated in 1974 by the Derg regime according to promulgation no.

47/1975 and proclamation no. 104/76 (Baker & Claeson, 1990; Ambaye, 2015), with private residential permit rights dominating the inner-city slum of Addis Ababa. Therefore, in Ethiopia, houses with tenure rights or old possession rights do not guarantee to be categorized as formal settlements. In other words, illegal land acquisition is not necessarily the binding criterion for informal settlement, following Drakakis's (1981) argument.

In Ethiopia, the binding criteria for informal housing identification are breaches of building standards and planning (Mahiteme, 2014). The informal settlement also includes houses constructed or land acquired without the requisite legal title of ownership by the municipality. In Addis Ababa, land acquisition through informal transaction on public land in the outskirts began in 1978 (Daniel, 2006) and the 1980s (Erena et al., 2017). Informal settlements have increased since 1994 (Minwuyelet, 2005) through the informal transaction of agricultural land by farmers (Samson, 2010; Erena et al., 2017). Informal settlements are located on the periphery of the southern, eastern, and western parts of Addis Ababa (Abagissa, 2019). Peri-urban Informal settlements are characterized by irregular shapes, large plot sizes, and small buildings disproportionately to the large unbuilt plot sizes (Minwuyelet, 2005). Peri-urban informal settlements are also characterized by a lack of infrastructure, utilities, and services and are located on hilly slopes and along riversides. Slums are the result of substandard housing built on legally or illegally occupied land. Nearly 70% of the houses are dilapidated and lack basic facilities and urban infrastructure services (UN-Habitat, 2017). Kitiya houses are self-initiated extensions and alterations in formal housing. The Kitiya houses provide housing for low-income groups while creating high densities and overcrowding (Tarekegn, 2000). Kitiya houses are common in the slums and informal settlements of Addis Ababa. Based on field observation and images, the Kitiya houses provide the slum with a pattern of densely built-up areas and a canopy of small buildings that challenge the identification of roof size, even with object-level identification. Slums are also characterized by a lack of rights of way for some residents, irregular local roads interspersed with some planned arterial and collector roads, and a lack of green and open spaces.

2.4.3.2. Urban morphology based deprivations based on the concept of slum ontological levels

The concept of slum ontological levels for characterizing and analyzing deprived areas

Researchers rely on the concept of the ontological properties of slums for characterizing deprived areas, including slums and informal settlements. Deprivation areas are extracted through the interpretation of impervious surfaces and permeable surfaces. The impervious surfaces are buildings, paved roads, and other man-made features. Permeable surfaces such as green space, open space, and vegetation extent are indicators of deprivation in physical aspects (Lemma et al., 2006; Sori, 2012; Kuffer, 2017). Conceptually, informal settlements or deprivation areas are identified and analyzed at the hierarchy of the spatial level, starting from the environment via settlement to the object level (Fallatah et al., 2018). Environment describes the surroundings of the settlement (its location with respect to neighboring land use) or areas with specific environmental conditions, such as hazardous areas. The settlement level describes the overall form, shape, and density. The object level considers the components of the settlement, such as the characteristics of buildings and roads (Kohli et al., 2012a).

Environment level analysis of deprived area

Based on the ontological concept of the slum, at the environmental level, location, and neighborhood characteristics are crucial dimensions. At the environmental level, neighboring land uses and areas with specific environmental conditions were analyzed in relation to informal settlements (Sliuzas & Kuffer, 2008; Hacker et al., 2013; De Risi et al., 2013; Oyinloye et al., 2018; Veriah, 2018; Abebe et al., 2019; Fallatah et al., 2022). Sliuzas & Kuffer (2008) related deprivations to environmental features, MDI, and informal settlements extracted from the VHR for Delhi, India. Hacker et al. (2013) integrates environmental criteria such as LULC (Land use and Land cover change) and socio-economic urban features to model deprivation areas based on slum evolution in Salvador, Brazil. A study in Ahmedabad, India, examined the vulnerability of slum areas to environmental hazards. The hazards include heatwaves, flooding, inundation, water scarcity, and water-borne infections (Veriah, 2018). The urban informal settlement neighborhood in Dar es Salaam (Tanzania) is vulnerable to flooding events. The flood event has a negative effect on slum settlements due to the poor quality of housing construction and high population density (De Risi et al., 2013). According to Muller et al. (2020), in six out of seven sample cities, the probability that a slum is in steep areas is higher than for informal settlement. The study in

metropolitan Durban showed a 3% net increase in informal settlement from 2015–2021 with a reasonable decrease in vegetated and water areas (Matarira et al., 2023). The temporal pattern of LULC analysis by different studies revealed where and when informal settlement occurred, which is useful for upgrading, strategic planning, and management (Abebe et al., 2019; Fallatah et al., 2022).

LULC has also been conducted to investigate informal settlement encroachment on agricultural land, forests, and farmer livelihoods (Oyinloye et al., 2018; Abebe et al., 2019; Azagew & Werku 2020). From 2003 to 2016, urban agriculture in Addis Ababa decreased by 11.9 percent, followed by a 3.7 percent decrease in the urban forest due to urban development (Azagew & Werku, 2020). Studies relate informal settlement to risk location for the purpose of interventions and research (World Bank Group and GFDRR, 2015; Weimann & Oni, 2019; African Development Bank Group and Urban and Municipal Development Fund, 2021; Bikis & Pandey, 2022). Informal settlements are found on riverbanks, in dense urban areas, and on the riverside of the rivers that flow into Addis Ababa: The Kurtumi, Kechene, Kebena, and Ginfile rivers (African Development Bank Group and Urban and Municipal Development Fund, 2021). Overcrowding and substandard slum and kebele housing, as well as a portion of it located in flood-prone riverbank areas, make it vulnerable to flood and fire (World Bank Group and GFDRR, 2015). Peri-urban Informal settlements are also found on sloppy land, in river buffers, and around religious institutions with fewer interventions (Bikis and Pandey 2022). Research is scanty on the impact of informal settlements on the global south's population health trends. Nevertheless, Weimann and Oni (2019) studied how crowding within houses increases the risk of exposure to infectious diseases and the risk of mental illness.

The deprivation areas and environmental features, vulnerability, and risks are highly related, reinforcing the requirement of further empirical evidence to propose sound strategies and interventions. Based on contemporary trends, high population density, an environmental health indicator, will be expected to increase in 2020 from what it was in 2002. Yet, population density, once a prominent feature of slums, has started to rise also in the suburban areas of Addis Ababa due to condominium housing and other formal housing development (Weldegebriel et al., 2021). Thus, a comparative study is pertinent to assess whether high population density is still a crucial factor or not for identifying slum areas in Ethiopia.

Settlement level analysis of deprived area

At the settlement level, texture properties represent the contrast between planned and unplanned settlements. In addition, slum areas depict a pattern of less vegetation and open spaces due to high building density (Kohli et al., 2012a). Several authors have identified informal settlements at the settlement level manually based on ontological properties and land use heterogeneity mixed with satellite images (Lemma et al., 2006; Sliuzas & Kuffer, 2008; Sori, 2012; Kuffer, 2017; Arif et al., 2022). Lemma et al. (2006) used irregular layouts and high built-up density to identify inner-city slums in the Addis Ketemea area of Addis Ababa, incorporating visual interpretative elements and focus group discussions. Sliuzas & Kuffer (2008) delineated typologies of formal and informal settlements, greater than 0.25 hectares from the interpretation of IKONOS images, environment features of the Aster image, and the MDI of Delhi, India. Kuffer (2017) identifies slum settlement areas based on small building size, high roof density, a lack of orderly road arrangement, and an organic layout. In earlier stages of informal settlement development, high building density was not the governing characteristic for lower-density areas (Sori, 2012; Kuffer, 2017). The lack of greenery, ecosystem services², and open space also distinguish slums from formal settlements. Slum sub-cities of Addis Ababa (Addis Ketema, Kirkos, Arada, and Lideta) have the lowest supply of ecosystem services, where income is low, housing is poor, and there is no space for a private garden or park (UN-Habitat, 2017). Moreover, the land use pattern of older and more densified slum settlements showed prevalent heterogeneity as opposed to the newly developed informal settlements (Arif et al., 2022). The regularized informal settlements were the result of the regularization conducted in 1996 [1988 E.C.], 2001/02 [1994 E.C.], and 2004/05 [1997 E.C.] (Hailu 2016; Erena, Berhe, Mammuru, and Soresa, 2017; Berhanu et al., 2022). The peri-urban informal settlement morphology depicts organic and spontaneous settlement layouts and a small building surrounded by disproportionately large plots at the infancy stage based on observation, with the built-up consolidated through time in some parts (Minwuyelet, 2005; Kassahun, 2010; Berhanu et al., 2022).

The manual delineation approach from VHR is a more accurate approximation of the ontology of informal settlements, though it is labor-intensive (Lilford et al.; 2012). Because humans can recognize and interpret subtle variations in form, that technology cannot (Samper et al., 2020), at

² The ecosystem services include carbon sequestration rate, air pollution removal, air temperature regulation, and runoff mitigation.

the settlement level, the human judgment of an array of criteria better identifies informal settlements. In addition to satellite images, Google Earth historical images are the most viable method for the direct mapping of informal settlements (Samper et al., 2020), and monitoring the temporal expansion of informal settlements. The automatic detection of settlements did not show sound result. The OBA of informal settlements in Jeddah showed that objects (vegetation, road network, and vacant land) were detected with high accuracy while the texture and the dwelling size generally failed to distinguish formal from informal areas (Fallatah et al., 2018). Other studies detected informal settlements from LR images for the first time by developing a brand-new ML data set specifically for informal settlement detection (Gram-Hansen et al., 2019).

Object level analysis of deprived area

A combination of attributes such as roof type, footprint, shape, and orientation can be used to identify buildings (Kohli et al., 2012a). Currently, building properties can be identified using pixel-based or object-based image classification. Yet, object-based classification is the most accepted approach. ML refers to a set of data-driven algorithms and techniques that automate the prediction, classification, and clustering of data (ESRI, 2017). Currently, the development of ML from pixel-based to object-based makes it possible to capture the object from multicolor images. ML is a subfield of computer science that allows the computer to learn without being explicitly programmed (Kalali, Richerson, Ouzunova, Westphal, and Miller, 2019). There are two types of ML: pixel-based and object-based. The OBA of slums identifies impervious surfaces in VHR by their ontological properties, such as roof materials, building footprints, shapes, orientation, type, height, neighborhood road access, regular or irregular structure, and the width of the road (Fallatah et al., 2018). Buildings can be extracted from an aerial photograph or VHR image based on their geometrical, spectral, and contextual properties. The geometric properties include shape and size, the spectral properties refer to tonal variation, and the contextual properties refer to the relationship between the target object and neighborhood (Jiayi et al., 2022). In general, the OBA extracts impervious surfaces using textural, spectral, semantic, topological, and geometric information and reduces within-class spectral variations (Desheng & Fan, 2010; Fallatah et al., 2018). Buildings have significant differences in size, shape, height, and function, which makes it possible to differentiate formal and informal buildings. Nevertheless, a complicated urban scene consisting of spectrally similar objects such as roads, bare ground, and parking lots makes accurate building extraction difficult (Huang et al., 2022).

OBA configures an appropriate segmentation scale for improving classification accuracy (Desheng & Fan, 2010). Currently, the OBA detects using VHR images from an aerial photograph or satellite. Studies claim that OBA is inefficient in detecting medium- and low-resolution satellite images (Assarkhaniki, Sabri, Rajabifard et al., 2021). On the other hand, the classification of VHR images using a pixel-based approach results in low map accuracy and causes mixed-pixel problems, particularly when classifying urban slum objects (Thomas et al., 2003). Moreover, pixel-based ML is constrained by the complexity of spatial and spectral diversity and local variations in settlements (Mathenge, 2011). There has been a lot of practice manipulating OBA for permeable and impervious surface detection. Study indicates that OBA is efficient in analyzing VHR images, while VHR images using the spectral feature provide poor-quality maps (Assarkhaniki et al., 2021; Fallatah et al., 2022).

The current object-based ML approaches, RF, Support Vector Machine (SVM), and CNN, have shown drastic improvements in the detection of objects from VHR. The RF algorithm outperforms the other ML algorithms in generalization and learning ability for impervious surface classification of spectral and textural features (Guo et al., 2020). RF can work with multi-band imagery and segmented images (ESRI, 2023). Furthermore, the RF classification has a low pixel-wise uncertainty prediction relative to the state-of-the-art model (Fisher et al., 2022). An RF is made up of multiple decision trees, and the final decision is reached through a decision tree majority voting. The constraint for RF is that many trees can make RF too slow and ineffective for real-time prediction. Hence, RF fails to consider the spatial neighborhood information of pixels (Breiman, 2001; Guo et al., 2020). ML outperforms SBSM (Survey based slum mapping) for scrutinizing object-based formal and informal building identification. If supported by local contextual ontological properties, the ML object-based approach performs better than the pixel-based approach (Kohli et al., 2012a), but it is computationally expensive (Leonita et al., 2018; Kuffer et al., 2020). The constraint of SBSM is creating inconsistencies through the inclusion of large, formal buildings and vegetation in the slum classification category. Thus, a combination of ML-based and SBSM may be the best solution for supporting slum-upgrading programs by combining top-down and bottom-up approaches (Leonita et al., 2018; Kuffer et al., 2020). Although the deep learning ML-based architecture faces challenges in the extraction of buildings in densely packed urban areas where individual roofs are difficult to extract (Abascal et al.,

2022), several authors have extracted buildings and deprived areas using CNN or DNN-based architectures of deep learning (Kuffer et al., 2020; Abascal et al., 2022). The limitation of CNN is that it requires a large amount of representative training data and has associated computational costs for training classification (Kuffer et al., 2022; Abascal et al., 2022).

2.5. Methodological Review

2.5.1. Overall methodological framework overview visa vise epistemology and worldview

The research was designed following Crotty's (1998) assessment of the methodology based on a philosophical stance, the epistemology embedded in the methodology, the strategy to link the method to the outcome. The study began by reviewing and evaluating the theoretical, conceptual, and empirical lenses of deprivation patterns from several angles. The theoretical position that best suits this research was pragmatism, according to the earlier evaluation described above. The pragmatism component of this study inherited characteristics from the legacy of the advocate worldview and the post-positivist worldview. The research's mixed methodology offers the chance to triangulate quantitative and qualitative approaches. The research strategy is a hybrid of sequential and transformative in that the theoretical lenses in the problem statement or introduction shape directional research questions intended to explore problems and create sensitivity to gather data from underrepresented groups, and it concludes with a call to action for policy interventions.

The transformative strategy is not geared to quantitative or qualitative perspectives; rather, the focus is on disadvantaged groups, and action solutions (Creswell, 2009; Donna, 2009). Based on the aforementioned perspectives, a quantitative and qualitative research design was drafted. The quantitative research design collects data based on a structured questionnaire, digital census data, and spatial data analysis. The qualitative parts of the questions were designed using an open-ended questionnaire for key informant interviews and individual case studies, observation, qualitative mapping, and ground verification. The procedure followed for epistemological stances, world view, theoretical framework, concepts, research design, and approaches are illustrated in figure-3.

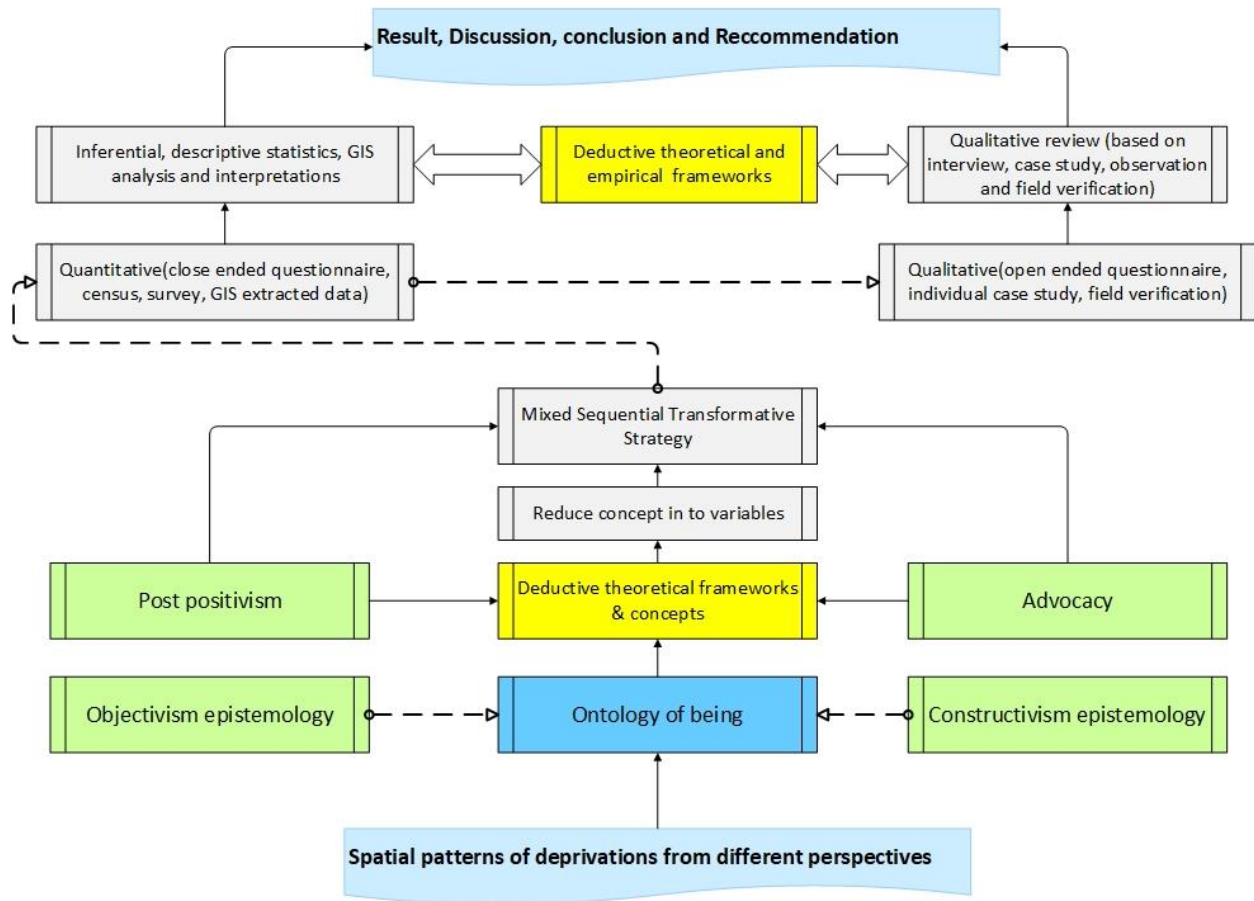


Figure 3 Epistemological Stance, Research Design, approach and deriving methodological framework.

2.5.2. Methodological review

Methodological review is a type of research synthesis that focuses on summarizing the state-of-the-art methodological practice of research in a substantive field or topic (Chong & Reinders, 2021). Thus, the study summarizes the research synthesis by briefly integrating the theoretical, epistemological, and conceptual frameworks with the overall research design and process.

2.5.2.1. Sustainable livelihood capital asset deprivations, the capability, and institutional aspects review for informal settlement areas.

The deductive theoretical framework includes theories on livelihood capital asset deprivation and asset theory of social preference, the Chicago school of thought, the Alonso-Muth-Mills model, the urban planning and land use politics theoretical frameworks, the slum ontological concept,

and the slum dichotomy model. The study is structured around a pragmatic worldview. The abstract concepts derived from deductive theoretical frameworks are reduced into measurable and concrete variables based on a post-positivist worldview (Creswell, 2003). Considering the advocacy worldview, the study designs to hear the deep wrath and feeling of deprivation by interviewing in depth the vulnerable groups in some aspects of deprivation. The institution and capability aspects, which are crucial along with livelihood capital assets in designing strategies, require a key informant interview. The research follows a pragmatic knowledge claim that takes elements from post-positivism and the advocacy worldview (Creswell, 2003; Creswell, 2009).

Then, considering the slum model theories (Stoke, 1962; Eckstein, 1991) and coupled with purposive sampling methodology, two areas were screened for further conducting systematic random sampling. Purposive sampling is non-probability sampling; samples are selected because they have characteristics that you need in your sample (Nikolopoulou, 2022a). After purposive sampling, systematic random sampling of a finite population is the logical procedure. Systematic random sampling is a probability sampling method that selects members of the population at regular intervals (Thomas, 2020). The sample size will be determined by the sampling formula of Yamane (1967), designed for a finite population. The above sampling procedures leverage the validity of the measure. Since validity ensures whether one can draw meaningful and useful inference from scores in a particular instrument (Creswell, 2009). The above procedure details and specific areas will be explained in detail in Chapter 3 based on the specifically selected areas.

Based on the epistemology and worldview framework (Creswell, 2003; Creswell, 2009), the research follows an explanatory mixed sequential design, which implies the collection and analysis of quantitative data is followed by qualitative data collection and analysis (Walker and Baxter, 2019). This research mainly uses primary sources of data directly collected by the researcher, as stated by the authors (Victor, 2017; Statistics Data, 2023). The primary sources of data were validated to enhance reliability and internal validation with statistically manipulated, collected, classified, or mapped secondary data sources (Victor, 2017; Statistics Data, 2023). Thus, the research envisages testing a theory by specifying narrow hypotheses and analyzing findings either to reject or fail to reject hypotheses in quantitative research. The qualitative part is exploratory research, which uses an interview with an open-ended questionnaire for interviewing

pertinent people for some length and an individual case study to capture the in-depth impression and real-life situation of the participant based on an advocacy worldview (Creswell, 2009; Reboji, 2013).

The research design is both descriptive and correlational. The descriptive research design aims to obtain information to systematically describe a population or object using quantitative and qualitative variables (Ansari, Rahim, Bhoje, and Bhosale; 2022). The descriptive research includes survey, observational, and individual case studies (Pawar, 2020) The correlation is a non-experimental design in which the researcher uses relational statistics to measure and define the level of correlation between variables (Ansari et al., 2022). External validity is the extent to which one can generalize the findings of the study to other situations, people, and settings (Bhandari, 2020). The systematic random sampling method, face-to-face interviews with respondents, observations, physical validation, and the rigorous selection of the sampling area through multistage purposive sampling increase the reliability and replicability of the study in other contexts. The question of whether the test items accurately reflect the theoretical domain of the latent construct they are supposed to measure is known as content validity (Ganesh, 1986; Ganesh, 1991). Content validity requires refining variables for questionnaires that portray in a reduced form the theoretical and conceptual underpinnings. Reliability and internal validity are enhanced by the researcher's providing a detailed account of the focus of the study, the informant's position, the basis for sample selection, and the triangulation of different methods of data collection and analysis (Creswell, 2009). The inferential statistics with significance alpha ($\alpha < 0.05$) leverage the reliability of the measure. The triangulation of findings from primary sources and secondary sources enhances qualitative reliability. Qualitative reliability indicates that a particular approach is consistent across different researchers and different projects (Creswell, 2009).

Regarding analysis, inferential statistics is a branch of statistics that makes use of various analytical tools to draw inferences about population data from sample data (Charles and Thevenow-Harrison, 2014), which requires dependable systematic random sampling for testing hypotheses and drawing sound conclusions. Some of the most common types of inferential statistics are regression analysis, hypothesis testing, confidence intervals, chi-square, and analysis of variance [ANOVA] (Simplilearn, 2023). Another inferential test is correlational

analysis, which is used to test the extent to which two variables are dependent on one another (Calvello, 2020). The triangulation of descriptive and inferential statistics is useful to culminate in a sound deduction by comparing and interpreting two statistical approaches. Here I describe the following inferential statistics: the chi-square test, the one-way ANOVA for unequal variance, the Pearson product moment correlation (PPMC), and the Spearman rank correlation (SRC) relationship. According to Kothari (2007), the chi-square test result showed a correlation between non-numeric variables at a significant level and with a defined hypothesis. One-way analysis of variance (ANOVA) determines whether differences between the means of at least three groups are statistically significant. Yet, one can use the Welch ANOVA to assess the mean of three or more groups, but you can also use it when your group has unequal variance and standard deviations (Frost, 2017). SRC is a non-parametric measure of rank correlation, or the Pearson correlation coefficient, between the rank variables (Wikipedia, 2023a). PPMC is the covariance of the two variables divided by the product of their standard deviations (Wikipedia, 2023b). The inferential statistical findings can be supported by descriptive statistics, which provide a summary of the sample being studied without drawing any inferences based on probability theory (Kaliyadan & Kulkarni, 2019). There are also qualitative methods: individual case studies and key informant interviews. The individuals' case study enabled finding in depth the real-life situations of vulnerable participants, following Rebolj (2013). Key informant interviews are qualitative, in-depth interviews with people who know what is going on in the community (Parsons, 2018).

2.5.2.2. The pattern of deprivation and inequality methodological review

The research reviewed the theoretical frameworks: culture of poverty," "concentrated poverty," "socio-spatial segregation," "bid rent theory," and "deprivation of sustainable livelihood capital assets." The research reviewed empirical and global frameworks of SDG. The research also reviewed the concepts of poverty, socio-spatial inequality, deprivation, vulnerability, and social-spatial exclusion. The study also reviewed the pros and cons of area-based and people-based policies and indexes for deprivations. The above deductive framework and concepts were translated into reduced, measurable, and concrete variables based on the "objectivism epistemology" and post-positivist worldview. The concepts of deprivation, poverty, socio-spatial inequality, vulnerability, and social exclusion also provide a framework for deriving potential variables.

According to Creswell (2009), determinism suggests that examining the relationship between and among variables is central to answering questions through surveys and experiments (Creswell, 2009). Based on the above determinism lenses, the intent is to measure the variables' interdependence without controlling or manipulating any of them, reflecting a correlational research design. Yet, in an experimental design, one manipulates an independent variable and measures its effect on the dependent variable. Other variables are controlled but cannot impact the result (Bhandari, 2021).

This study's primary data source is CSA census and survey row data. The primary source of data includes the original census row data without any statistical operation, analysis, or classification, in addition to primary data obtained from surveys (Victor, 2017; Statistics Data, 2023). Vectorized or digitized information from satellites, or information obtained from published or unpublished documents, are secondary sources (Victor, 2017; Statistics Data, 2023; ESRI, 2023). Thus, the research also integrates secondary source information from a census-published document about population projection (CSA, 2013a) and digitized information obtained from the Addis Ababa city administration. Primarily, from the obtained primary and secondary sources, variables describing the theoretical and conceptual frameworks were refined to ensure, as stated by Creswell (2009), that the variables or indicators measure the concept and theoretical framework they are intended to measure. The triangulation of the deductive framework with the inductive approach of PCA leverages the validity of the content. The internal validity of the research can be enhanced by triangulating the concept or construct refined through deductive, theoretical, and empirical frameworks with the inductive, empirical approach findings of PCA. For instance, measures of psychological constructs are validated by testing whether they relate to measures of other constructs as specified by theory (Strauss & Smith, 2009). The external validity can be enhanced by comparing the inductively derived PCA robust indicators and factors findings to other settings such as the SDG and previous empirical and theoretical frameworks (Bhandari, 2020). The reliability, which is the overall consistency of a measure, of the sample for performing PCA was confirmed with the KMO (Keyser-Meyer-Olkin Measure of Sampling adequacy) test. The BTS (Bartlett test of sphericity) measures the factorability of the inter-correlation matrix, whether it is correlated or uncorrelated (Vijaya, 2010; Pishghadam, Noghani, and Zabihi, 2011), to enhance the reliability of the measure. The triangulation of the findings of PCA with other empirical and theoretical frameworks further enhances the internal validity and reliability of the measure.

Multi collinearity refers to a strong correlation between independent variables in multiple regression analysis (Botsi, 2017), which degrades the reliability of the independent variable prediction. The research design is descriptive and correlational. The correlation research design analyzes the interdependence between two or more variables without controlling the impact of other variables that influence a factor or component. The descriptive research design part analyzes the data using descriptive statistics (Pawar, 2020; Ansari et al., 2022). Longitudinal research is also pertinent for analyzing development trends (Pawar, 2020). In this study, there is a need for analyzing and interpreting the deprivation and inequality patterns over time. Since the purpose is to implement a scientifically rigorous methodology, the automatic statistical weighting and ranking deprivations based on factor scores provide an advantage relative to the non-statistical weighting method. The unitary weighting method and asking for opinions are simple but subject to arbitrary and subjective judgment (Wong, 2006). In statistics, regression validation is the process of deciding whether the numerical result obtained from regression analysis, quantifying the hypothesized relationship between variables, is acceptable as a description of the data.

According to Mengul-Macennle, Marcos, and Gonzales (2015), MVAT techniques like PCA are made to analyze multiple variables for each subject being studied. They are best suited for the study of large data sets and for determining the cause-and-effect relationship between variables. The MVAT of PCA or factorial analysis can be done after candidate variables have been screened using PPMC to further refine the degree of correlation between variables. The derived components in MSAT statistical weighting serve to clarify the main idea through an empirical connection between several indicators, which qualifies the MSAT technique for policy targeting (Wong, 2006). The inductive approach of MSAT extracts patterns, components, and indications from observation and develops theories through a sequence of hypotheses (Bernard 2011). There are two familiar MSAT techniques, which are PCA and factor analysis. The MSAT's techniques are used for data reduction and finding patterns in the causal relationship between variables. PCA's approach to data reduction is to create one or more index variables (components) from a large set of measured variables through linear combination or a weighted average of the set of variables. Yet, factor analysis is a model of measurement of a latent variable, through the relationship it causes in a set of y variables (Grace-Martin, 2023). PCA overrides other MSAT methods (i.e., factor analysis) for the MDI model. The benefits of PCA are the following: an orthogonal transformation of the original variables into a new set of variables, maximization of

the variance of variables, and reduction of redundancy. In addition, PCA derives small diagnostic factors from a large set of variables, and it is advantageous for giving more weight to unequally distributed assets between cases (Filmer & Pritchett, 1998; Fabrigar, Wegener, MacCallum, Strahan, 1999; Vyas, Kumaranayake, 2006; Fam, Ismail, Maukar, Yanto, Prastyo, Chuan, 2018).

To enhance the pattern analysis of variables for revealing the local pattern, the LISA (Local Index of Spatial Association) tool is appropriate, while for the overall spatial pattern analysis, Moran's I tool is an appropriate technique. The spatial autocorrelation (Global Moran's I) measures the overall spatial autocorrelation based on feature locations and feature values simultaneously; the index ranges between -1 and +1. If the values in the dataset tend to cluster spatially, the Moran's I index will be positive; if a high value tends to repeat other high values and tend to be near a low value, the index will be negative; and the index will be zero if positive cross-product values balance negative cross-product values (ESRI, 2022a). LISA can be interpreted as an indicator of local pockets of non-stationarity or hot spots, like the GI* statistics of Gettis and Ord tools. Yet, they are also used to assess the influence of individual location on the magnitude of global statistics (Moran's I) and to identify outliers (Anselin, 1995). Since LISA identified local pockets that were strongly positively and negatively associated with one another, it is suitable for identifying polarization of spatial inequality and screening the most and least deprived small local administrative units.

To design a standardized MDI tool that monitors deprivations, there are two MDI construction scenarios. Regarding the first scenario, the first component that loaded highly on many variables was a measure of multiple deprivations (Bernard, 2011). The second scenario is to first develop an NSMDI (non-standardized MDI), considering the following: 1) the percent of variance explained by components with eigenvalues > 1 , 2) the total variance explained by considered components for the MDI, and 3) the component score for each disaggregated spatial unit (Vijaya, 2010). The standardized MDI can standardize the NSMDI with a linear function between the absolute highest and lowest score (Vijaya, 2010; Lu, 2019). For instance, the UN human development index for monitoring poverty was developed by refining many dimensions and indicators of social and economic development, and finally, the index was produced considering three factors: income, longevity, and educational attainment (UNDP, 1997). The MDI tools are used by countries for resource allocation for urban regeneration and other applications. For instance, from 2001-02 to 2010-11, 500 million pounds per year were allocated directly to the

most deprived local authorities in England based on MDI through the neighborhood renewal fund (McLennan, n.d). The descriptive research design uses percentages, maps, or graphs to describe the situation and analyze deprivation versus population and population density. The interpolation of the MDI score and population density in GIS software allows variations in deprivation in accordance with urban morphology and population density. In sum, the above-mentioned overall analysis justifies area-based policy if there is a large and disproportionately deprived population, overlaps of deprivation problems, and concentrated poverty.

2.5.2.3. Urban morphology-based deprivation.

This research bases the concept of slum ontology on environment, settlement, and object levels for differentiating deprivations based on an urban morphology framework (Kholi et al., 2012a, 2012b). The informal settlement and slum definition, empirical frameworks and global SDG frameworks based on the global and context of Ethiopia provides a theoretical lens for interpreting deprivations based on the urban morphology framework (Mahiteme, 2007).

The research incorporates elements of post-positivism and constructivism in epistemology. The focus of the research design is problem-centered, pluralistic, real-world practice, and it is not committed to any philosophical stance (Creswell, 2003). Thus, the design of the research is both descriptive and experimental. Descriptive research design is a type of research project that aims to obtain information to describe an object, situation, or population. Experimental research is aimed at analyzing the cause-and-effect relationship between independent and dependent variables by controlling and manipulating other variables' impacts on dependent variables (Pawar, 2020; Ansari et al., 2022; Bhandari, 2021). The descriptive research design part has a quantitative and qualitative nature. The mapping of deprived areas by subjective interpretation and classification of settlement indicates the qualitative nature of the design, while the pixel-based classification of LULC and object-based classification of the VHR image reflect the quantitative nature of the design. The logistic regression for environment-level analysis reflects the experimental nature of the design. The study's intent is to analyze and interpret the development trends at the city level as stated in longitudinal research (Pawar, 2020).

The sources of data include primary and secondary sources. Based on ESRI (2023), satellite or aerial imagery can be described as a direct measurement or primary data source. Secondary

sources, for instance, include digitizing and obtaining vector information from imagery. If classified imagery obtained through ground verification is obtained from different sources, the obtained image is considered a secondary source. Victor (2017) claimed that sources that have undergone statistical treatment are considered secondary sources. The longitudinal research design involves multiple observations, repetitive use, and experiments that involve the same group of people over a period of time (Pawar, 2020). The research compares the cause-and-effect relationship between the environment and the location and neighborhood characteristics of the environment at different times, explaining the longitudinal research design.

Regarding the environment, the study reviews the methodological tools used for relating neighborhood characteristics and location with urban morphology-based deprivations. The study reviewed how different authors used different analysis tools such as chi-square, PPMC, canonical discriminatory analysis, percentage, and land use change to relate to deprived areas (informal settlements) with environment location and neighborhood characteristics. At the environment level, the study refines the environment-based location and neighborhood characteristics as independent variables and the deprived or less deprived nature of the settlement as the dependent variable. Thus, logistic regression is the appropriate alternative for solving the above problems since it predicts binary outcomes by relating independent variables of any measurement level (Chao-Ying, Joanne, Kuk, Gary, 2002; Hoffman, 2015). For experimental research design, internal validity refers to whether the manipulation of the independent variable makes a significant difference in the dependent variables to run the model (Jones & Bartlett, 2017). Thus, to validate whether the obtained result regarding the set hypothesis or research question is acceptable, there are tests such as the Wald test, the likelihood ratio test, and the omnibus test of the model coefficient that check whether the independent variable is statistically significant to run the model (Leon, 1998; Chao-Ying et al., 2002). The reliability is obtained by the Nagelkerke (r^2). The Nagelkerke measures how useful the independent variables are in predicting the dependent variable (Ball, Bewick, Cheek, 2005). Yet, the Nagelkerke (r^2) depends on the number of independent variables explaining dependent variables. Yet, in this case, the study's interest is only in a small number of independent variables of the environment explaining urban morphology-based deprivation. From the independent variables, the LULC extracted from the primary source (row Land Sat 8 image) was verified by computing the confusion matrix by

selecting samples from the VHR image, while the land use prepared by ESRI from sentinel 2 10 m resolutions using deep learning has already been verified by ESRI (2022b).

At the settlement level, deprived areas are distinguished based on texture, shape, diversity, and orientation. In general, the physical characteristics that identify informal settlements are a lack of greenery, a lack of open space, irregular layouts, organic roads, and high building density (Lemma et al., 2006; Sliuzas & Kuffer, 2008; Sori, 2012; Kohli et al., 2012a; Kuffer, 2017; Arif et al., 2022). Thus, since the study is aimed at delineating and interpreting urban morphology-based deprivations, the denominator for delineating informal and formal settlements is a subjective judgment based on the concept of slum ontology—whether the settlement is deprived or not based on VHR. The approach is descriptive research design and qualitative mapping based on the human experience of ontological properties, supported by field verifications. Based on the slum ontology (Kohli et al., 2012a, 2012b), indicators and interpretation elements were derived. The indicators were settlement shape, settlement density, and settlement diversity as extracted and seen from VHR imagery, while the interpretation elements were settlement texture, building shape, road shape, built-up density, and land use heterogeneity. The aim of interpreting deprivations from urban morphology is to interpret, describe, and quantify the percentage and growth trend of the deprived area, which makes it a quantitative version of a descriptive research design. Moreover, at the settlement level, since the research objective also includes quantifying deprived areas at different times, it has a longitudinal research design element. The proportion of settlement delineation versus ground verification verifies the reliability of the classification.

Buildings with and without deprivation are often distinguished at the object level based on morphological characteristics such as geometrical attributes [shape and size], spectral attributes [tonal variations], and contextual attributes [connection between the target object and neighborhood] (Jiayi et al., 2022). Based on the slum ontology concept, object-level identification includes orientation, shape, footprint, and roof types. In addition, neighborhood features, such as the type and breadth of the road, as well as the regular and irregular structure of the road, are also useful for interpretation (Kohali et al., 2012a, 2012b). The above-described detailed information can be extracted from a VHR image, like an aerial photograph. The building-level methodology aimed to test deprived or less deprived building identification by aerial photographic imagery. Based on ESRI (2023), satellite or aerial imagery can be described

as a primary data source. This study has a descriptive research design because it also aims to interpret the findings and describe the obtained results using an index or percentage. The current familiar object-based ML approaches are RF, SVM, and CNN. Since the object level classification is computationally demanding and requires a large processing workstation, studies can be conducted using convenient sampling (Nikolopoulos, 2022b) for testing the object level classification, and comparing the deprived and less deprived objects.

From the overriding urban building extraction methodology, object-based ML outperforms the approaches of SBSM to detect impervious and permeable surfaces, while the detection of objects using spectral features from VHR provided poor-quality maps for impervious surfaces (Assarkhaniki et al., 2021; Fallatah et al., 2022). Moreover, OBA derives spectral, textural, semantic, topological, and contextual information (Desheng & Fan, 2010; Fallatah et al., 2018; Jiayi et al., 2022). From the object-based perspective, the study uses RF since CNN, although a better approach, requires a lot of the training data set and memory (Kuffer et al., 2020; Abascal et al., 2022). Software like ArcGIS Pro can perform object-based RF classification. The confusion matrix gives the reliability of the evidence that the object-based classification's user accuracy, producer accuracy, and kappa coefficient are reported to reveal the reliability of the classification. A confusion matrix is a table that is used to define the performance of a classification algorithm (Singh, Singh, Singh, Singh, 2021). The regularity of the building roof, green, and other permeable surfaces is evaluated by computing the shape index (Bhardwaj & Kumar, 2019).

2.6. Research gaps

Based on SDG 11, there is a growing interest in quantifying the proportion of population living in deprived areas (informal settlement, slum, and inadequate housing) (UN-Habitat and Global Urban Observatory, 2019). Yet, in the case of Ethiopia and Addis Ababa, the lack of a census since 2007 and the postponement of the census in 2018 have constrained the forecast of the real population figure for 2020. This, in turn, constrained the estimation of the population size living in informal and formal settlements based on deprived and less deprived areas, as per the interest of this research. Different sources provide different figures for the same year's population size. For instance, based on the world-gridded population data, the population of Addis Ababa was 3,292,785 (2010) and 3,406,003 (2020), respectively, with an annual growth rate of 0.344%. On

the other hand, the projected population size by the CSA for 2010 and 2020 was 2,912,000 and 3,689,000, respectively (CSA, 2013a), giving a 2.67% annual population growth rate. The above figure controversy indicates that there is a drastic population growth difference in the estimation of population size. The WorldPop explicitly stated the uncertainty of the population estimate for countries that have not had a census for a long time. The WorldPop top-down modeling method takes a global database of administrative unit-based censuses and projection counts for 2002–2020 and utilizes a set of geospatial datasets considering built-up and residential location to disaggregate them as counts for a 100m by 100 m grid cell (WorldPop University of Southampton, 2023). On the other hand, the census forecast for the population size for 2020 is uncertain since the forecast originated from the 2007 census without considering the current spatial pattern of built-up and residential land use dynamics. One benefit of the WorldPop estimate is that it considers the spatial pattern of population distribution based on built-up areas, residential land use, and census estimates, which is useful to approximately estimate the proportion of population per area and compute population density. The WorldPop population data has been criticized due to the underestimation of population size (Thomson et al., 2021).

Chapter Three: Research Methodology or Materials and Methods

3.1. Study Area

The study was conducted in the Addis Ababa citywide area and the selected informal settlement areas of Addis Ababa. The selected case study areas were from Addis-Ketema and Kolfe-Keranyo sub-cities. From Addis Ketema sub-city, the selected sample survey area was Wereda 07 (hereafter called an inner-city slum). From Kolfe-Keranyo sub-city, the selected sample survey area was wereda 03, a peri-urban informal settlement area (hereinafter called peri-urban).

3.1.1. Background to Addis Ababa

Addis Ababa, founded in 1887 by Emperor Menelik II and Empress Taitu, is the capital and largest city of Ethiopia. It is located between $8^{\circ}55'$ and $9^{\circ}05'$ North Latitude and $38^{\circ}40'$ and $38^{\circ}50'$ East Longitude. Altitude varies between 2100 and 3000 m (Yeshitela, n.d.). The city lies at the foot of Mount Entoto and forms part of the Middle Awash. It has a subtropical highland climate. The wet season is from June to mid-September. The dry season is from mid-November to January (Wikipedia, 2023c). Addis Ababa evolved around the imperial palace, the market [Arada], and the church [St.george] (Pankhurst, 1961). Western planning practise was introduced along with the Italian occupation of Ethiopia [1935 - 1941] (Tufa, 2008).

The city administration of Addis Ababa was made up of 10 sub-cities and 99 Weredas' when this study began (Figure 4). Addis Ababa has a dual identity as the federal capital and an autonomous administration commensurate with the state (UN-Habitat, 2007). The area of Addis Ababa, based on the 2007 census area delineation, was 52,743 hectares based on my own computation in GIS. The city population of Addis Ababa was 15, 000 in 1889, 3.3 million in 2010 (UN-Habitat, 2017), and 3.7 million in 2020 (Ethiopian Statistical Service, 2021).

It is home to 68% of urban jobs. The per capita income was USD 1,359 in 2015. The city of Addis Ababa has an 80% literacy rate, higher than other parts of the country. 72.27% of Addis Ababa residents were without access to adequate sanitation facilities (UN-Habitat, 2017). 45–50% of the city's solid waste was collected (World Bank Group and Cities Alliance, 2015). 50–55% of the population of Addis Ababa had access to either unsafe water or bought water at a

high cost from shops (UN-Habitat, 2017). In 2018, the Addis Ababa road network was 5,915 kilometres long (World Highways, 2018).

The population density of Addis Ababa was 160 and 190 people per hectare in 2007 and 2016, respectively (AACPPPO [Addis Ababa City Planning Project Office], 2017). The density of Addis Ababa is increasing despite urban renewal having displaced 28,584 HHs from 2009–2016 in Addis Ababa (ORAAMP [Office for the Revision of Addis Ababa Master Plan], 2001), while since 2012, the Ethiopian government has focused on the redevelopment of the inner city for the accumulation of high-end developers (Weldeghebrael, 2022). The inner city is mostly made up of old, unplanned, dilapidated, and kebele rental housing stock, though some have their own private tenure rights, and some inner-city illegal housing exist (Elias, 2008; Issa, 2021). The inner city of Addis Ababa lies 4.5 km from the city's main CBD, covering an area of 6050 hectares and housing 40% of the city's population (Weldeghebrael, 2022). See figure 4 for location map of Addis Ababa.

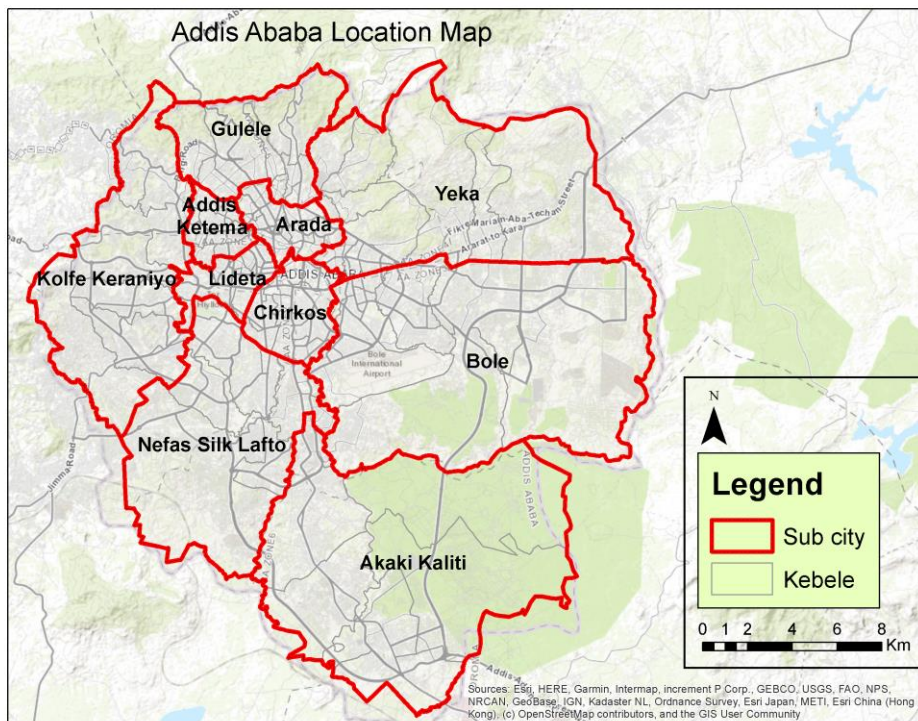


Figure 4 the Location of Addis Ababa

The purely inner city consisted of 32 percent of the projected population (CSA, 2013a), which lived in 7.8 percent of the area. The purely inner-city slum sub-cities are Lideta, Kirkos, Addis Ketema, and Arada. The old CBD is in the Addis Ababa inner-city market area of the Addis Ketema sub-city (ORAAMP, 2001). Merkato, situated in the old CBD, is the largest open market in Africa (Wikipedia, 2022). The main expansion areas of peri-urban informal settlement are in the dominantly suburban sub-cities of Akaki Kaliti, Kolfe Keranyo, Yeka, and Bole (Abagissa, 2019). The peri-urban informal settlement is an area subject to coercive bulldozing, little infrastructure, and uncertain or no tenure rights (Elias, 2008; Issa, 2022; Tesfaye, 2019).

3.1.2. Background to sub-cities of Informal settlement areas

3.1.2.1. Addis Ketema Sub city

Addis-Ketema sub-city has 10 weredas. It is the old inner-city slum in Addis Ababa that covers 11% of the total area of 54,000 ha, which includes the sub-cities of Lideta, Kirkos, Addis Ketema, Arada, and some parts of Kolfe-Keranyo, Gulele, and Yeka sub-cities (Elias, 2008). The inner-city slum in Addis Ababa is the legacy of houses constructed informally before the 1974 revolution (Solomon & McLeod, 2004). Addis Ketema borders the districts of Gulele in the north, Arada in the east, Lideta in the south, and Kolfe Keranyo in the west. Mercato, Africa's largest open-air marketplace, is in Addis Ketema sub city. According to CSA (2013a), the projected population of Addis Ketema sub-city is 320,053 in 2017. It consists of 10 weredas with an area of 7.41 km² (Addis Ababa City Government, 2011). According to Zafu and Peter (2014), the Addis-Ketema sub-city inner-city slum is aged (on average, 50 years old), centrally located, dilapidated, overcrowded, formalized tenure dominated by tenant houses, low-income people, subject to flooding, and endowed with poor services (Zafu and Peter, 2014).

3.1.2.2. Kolfe keranyo Sub city

Kolfe Keranio sub-city is one of the newly established ten sub-cities of Addis Ababa. It is located in the western part of the city, between 8°57'00"N and 9°05'24"N and between 38°39'36"E and 38°43'12"E. It is 9.6 km from the center of the city and has an estimated total area of 6400 hectares. It consists of 15 weredas. It is considered one of the semi-peripheral parts of the city and is recognized for its informal business activities. According to CSA (2013a), the

population of Kolfe Kenayo is projected to be 537,561 in 2017. It is the dwelling for multitudes of migrants who arrived from different parts of the country (Betelehem, Demiye, Eyob, Rahwa, Tigist, Yishak, 2006; Addis Ababa City Government, 2011; M.G./Egziabhere, personal communication, June 12, 2018). The history of illegal subdivisions of Kolfe Keranyo has been traced back to 1978 (Daniel, 2006). Yet, according to Kassahun (2010), the peri-urban informal settlements evolved in the 1990s and have increased since 1994 (Minwuyelet, 2005). Some of the tenures of peri-urban areas were regularized using a 1994 E.C. (Ethiopian Calendar) aerial photograph and a 1997 E.C. satellite image (Addis Ababa City Government, 2012). The peri-urban proliferation of informal settlements has become rampant after regularization (World Bank, 2016). The peri-urban informal settlements are highly susceptible to flooding, poor sanitation, and water services. The land is acquired mainly by buying from farmers and informal sub dividers, with a small percentage acquired through peasant authority permission (Daniel, 2006). The Kolfe Keranyo peri-urban settlement lies at the edge of Addis Ababa.

3.1.3. Background to Addis Ababa Informal Settlement selected areas

3.1.3.1. The Inner-city slum

It is in the Addis-Ketema sub-city Wereda 07. Wereda 07 consisted of four Kebele administrations (currently *ketena*) based on Derg regime kebele jurisdiction (kebeles 29, 30, 32, and 34). The estimated population size was 32,646 and the growth rate was 3% in 2018 (CSA, 2013a, 2013b). The total surveyed population and HHs size of the inner-city slum were 2435 and 404 in 2018, respectively. The mean household size was “6” for sample survey. Yet, the mean HHs was 4.8 people based on CSA (2007). The area and population densities were 49.88 ha and 654 people/hectare in 2018. 59.4% of the total HHs were FHHs (Female-Headed Households). The over crowdedness was 4.01. About 25.3% of HHs had a mezzanine floor (‘kot’ in Amharic) for renting/living. About 61.3% of HHs had lived in their dwelling unit for >30 years. The largest ethnic group was the Amhara (38.4% HHs). The majority (74.3%) of the dwellers followed the Ethiopian Orthodox Christian. The Married and Widowed HHs constituted 44.3% and 27.5 %, respectively. About 20.5% of HHs were learning up to Read and Write. 65.5% were migrants. About 97.52% of HHs had de jure tenure right (Permit Right, Kebele house renter, Municipal house renter). Based on additional questions on previously surveyed HHs for Kebele 32 and 34 (consisting of the current two *ketena*) of Wereda 07, 39.3% of HHs rented beds for

temporary and recent migrants. The above findings depicted Alonso’s model regarding how the poor outbid the rich and survive in a CBD (Central Business District) through overcrowding, renting, and exploiting the reduced transport cost opportunity (UN-Habitat, 2003a). About 90.3% were involved in CBO such as ‘Edir’ and ‘Ekub’. Election participation for 20 % of HHs was low and very low. About 43.6% of HHs earned incomes below the absolute poverty line of Ethiopia (< 599 birrs per month per Adult Equivalent in 2016). The average mobility from work to home was 13 min for inner-city slums due to its nearness to old CBD. The unemployment rate for the 18–64 and 18–29 age groups was 33.71 % and 24.33 %, respectively. See figure 5 for location map of Addis Ketema Wereda 07 area of the inner-city slum.

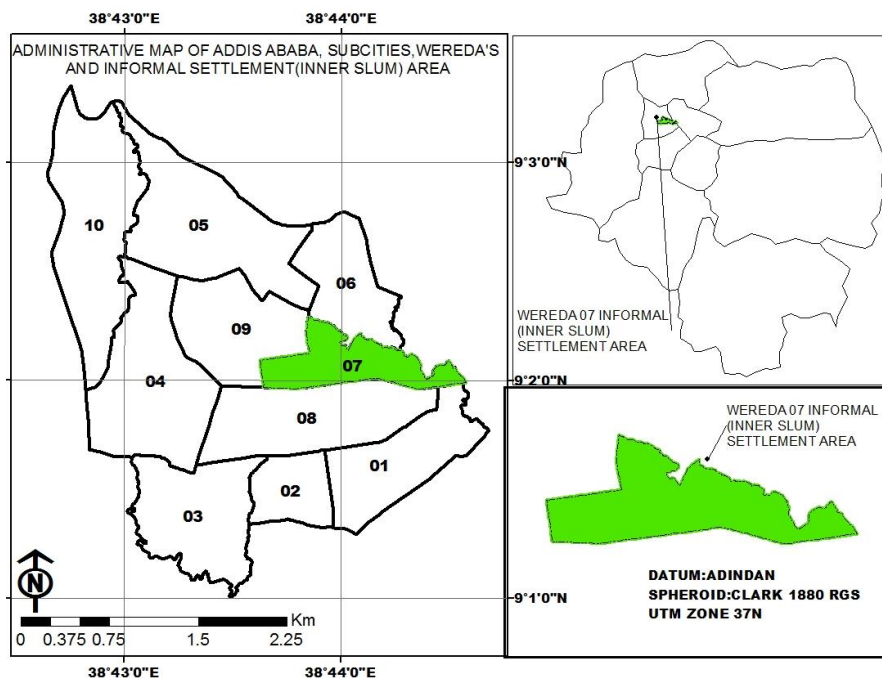


Figure 5 Addis Ketema subcity Wereda 07 study area (inner-city slum)

3.1.3.2. The Peri-Urban

Kolfe-Keranyo Wereda-03 peri-urban is a settlement mainly formed through informal land transactions (see figure-6). The peri-urban population was scanty and spontaneous during the 2007 Ethiopian census period; therefore, there was no officially recorded figure per geographic jurisdiction. Yet, based on information from the Wereda-03 building permit office and residents, there were 2500 HHs in 2018. See figure6 for the location map of Kolfe Keranyo Wereda 03 peri urban area.

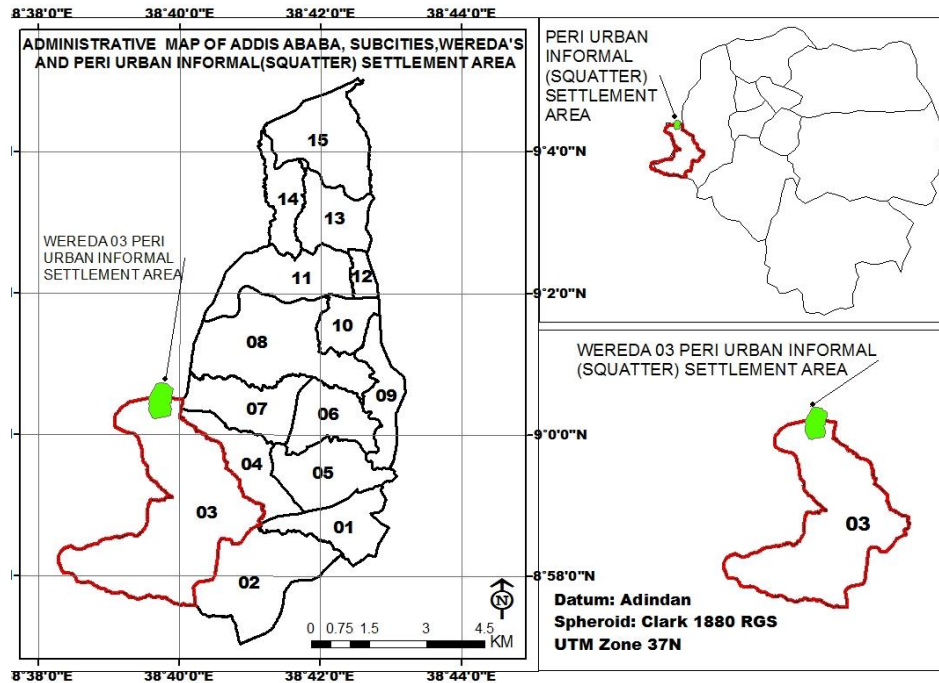


Figure 6 Kolfe Keranyo Wereda 03 peri-urban informal settlement area

Considering 4.35 HHs for the kolfe keranyo sub-city (CSA, 2007), the estimated population was 10,875. The area and population densities for 2018 were 45.96 ha and 237 persons/hectare, respectively. The total surveyed population was 1212 (HHs = 252) for 2018. The MHHs constituted 78.57%. The mean household size was “4.8”. The over crowdedness was 2.67 people per room. 100% of peri urban HHs had no mezzanine floor. 75% of the peri urban HHs had lived in their dwelling units for less than ten years. From the total HHs, the Gurage ethnic groups and Muslim religion followers were 50.4 % and 58.7 %, respectively. The Widowed HHs constituted 3.6%. HHs attended 5–8 grade was 48.4 %. Migrants constituted 90.5% of the HHs. 81.7% of HHs had no recognized tenure (unauthorized dwellers/ renters). About 76.6% were involved in CBO. Election participation for 24.6 % of HHs was low and very low. About 22.6% of HHs earned income below the absolute poverty line of Ethiopia. The average mobility from work to home was 42 min. The unemployment rate for the 18–64 and 18–29 age groups was 20.4 % and 15.63%, respectively.

3.2. Research Design

3.2.1. Research design for specific objective 1

In line with Walker and Baxter (2019), the research followed an explanatory sequential design where quantitative analysis provides general comprehension while qualitative data from individual case studies and interviews refine and explain the statistical result. The research has transformative strategy elements as the focus of the research is on gathering information from deprived and socially excluded groups, not on quantitative or qualitative methodology bias (Donna, 2009; Creswell, 2003). Thus, based on the descriptive research design, the research collected information using a combination of interviewing each individual HH, discussion with officers and officials, individual case studies, and observation. The research also uses a correlational research design (quantitative). The correlational research design analyzed the variables using the statistical tools of the chi-square test (χ^2), one-way analysis of variance for unequal variance (OWAUV), PPMC, and SRC. The analysis from the correlational research design is validated with the descriptive research design of quantitative and qualitative variables such as percentage or proportion, individual case studies, and key informant interviews. The theoretical and conceptual lens of multiple aspects of livelihood capital asset deprivations, in addition to regulatory framework reviews, provides bases for defining variables, narrow hypotheses, or questions for quantitative research. The research falls into the category of a cross-sectional survey since data were collected at one point in time in 2018.

3.2.2. Research design for specific objective 2

The research design includes correlational and descriptive methods. The correlational research design is due to the intent of the research, which is to determine whether there are overlaps and interdependences of the deprivation problem or indicators as well as the spatial pattern of deprivations without controlling the effect of other independent variables on one or more components or factors using PCA. The descriptive research design is also used to analyze the proportion of the deprived population as a graph or percentage by cross tabulating the deprivation score and population. The descriptive research design is also used to map the category of deprivation and provide background information regarding the central tendency figures of Addis Ababa city. The research design is longitudinal, as the intent of the research is

to compare deprivation patterns for MDI 2007 and MDI 2016 to interpret the change in deprivation patterns and trends over the course of time.

3.2.3. Research design for specific objective 3

The research design is both descriptive and experimental. The descriptive research design has the nature of pragmatics, incorporating quantitative and qualitative elements. The qualitative nature of descriptive research answers the question of where formal and informal settlements are subjectively located by classification based on the interpretation of morphological properties from a VHR 2010 aerial photograph with 0.2-meter resolution and a recent Google image from 2022. The quantitative nature of the descriptive research design quantified the defined area, percentage, and growth trends of deprived and less deprived areas. In addition, the quantitative part of the descriptive research design analyzes, by supervised pixel-based classification, the existing reality of LULC from primary sources of Landsat 8 images. The study also uses secondary sources of LULC prepared by ESRI from Sentinel-2 10m resolution images using deep learning methods supported by ground verifications. The research also has an experimental design, conducted between the dichotomous nature of the dependent variable and environment-level variables extracted as independent variables by controlling the effect of other variables affecting urban morphology-based deprivations as a constant.

3.3. Data Types

3.3.1. Data type for specific objective 1

The analysis of this study has both quantitative and qualitative data. Here, the study mentioned the quantitative data type used in the analysis in line with the close-ended questionnaire of the study in table-1. The details of the variable value and categories are attached to the closed-ended questionnaire attached to Annex 1 and 2 of this paper and key informants interviews on annex-3. Moreover, the details of the variables are also analyzed and supported with descriptive statistics in the analysis part. The livelihood capital asset deprivations (financial, physical, human, social, and natural) were analyzed from the primary data source, but there were also secondary sources used only for verification of the primary sources..

Table 1 the data used in deprivations of livelihood capital asset quantitative analysis disaggregated by financial capital, human capital, physical capital, social capital, and natural capital.

Ser.No	Data type and measurement levels	Ser. No	description
1	Financial capital	4	Social Capital
	-Income expenditure per AE (ratio) -Food expenditure %(ratio) -Energy and Light Expenditure %(ratio) -House rent expenditure%(ratio) -Income per Capita (ratio)		-CBO class (nominal) -HH participation in the election (nominal)
2	Human capital	5	Physical Capital
	-Migration status of HH (nominal) -Length of residence by HH (ratio) -Unemployment (18-64) percent Per 15-64 productive force (ratio) -Youth Unemployment (18-30) per 15-64 productive force (ratio) -Educational Status of HH (nominal) -HH Family members' educational status (nominal) -HH Marital Status (nominal) -HH Occupational Status(nominal) -HH Employment Status (nominal) -Over crowdedness or person per room (ratio) -HHs grade level (ordinal)		-Sanitation Vulnerability (ordinal) -Water Vulnerability (ordinal) -Tenure right (nominal) -Water Source of the HH (nominal) -Building Conditions (ordinal) -Distance in meter from existing road (ratio) -Distance from Social Services of health station and high school(ratio) -HH mobility [Transport work to home in minutes] -Building area in meter square per family size (ratio) -Parcel area in meter square per family size (ratio)
3	Natural Capital	6	Secondary source Information
	-Slope classification (ordinal) -HH location in relation to environmental hazard (nominal) -Distance from a polluted river (ratio)		-Parcel, road, and building information (inner-city slum) -Rental house information for Wereda 07(inner-city slum) -Building and road information for Wereda 03 (peri-urban)

3.3.2. Data types for specific objective 2

The SPSS correlation analysis refined 23 and 11 indicators for the MDI 2007 and MDI 2016 analyses, respectively. Kebele was the disaggregation unit for population and HH-level data. By screening indicators that describe the concept or construct through the deductive theoretical lenses and the inductive empirical approach of MSAT, the research enhanced the internal validity of the variables. The findings were triangulated within the theory, analysis, and SDG contexts to ensure external validity. The dimensions and indicators for MDI 2007 and MDI 2016 are described in Table 2.

Table 2 Dimensions/factors, indicators, and description for MDI 2007 and MDI 2016.

Factors MDI 2007	Indicators	MDI Year	Indicator Description
Education	Illiterate population	MDI 2007	% of illiterate family members of the HHs
	Degree level education deprived	MDI 2007	% family members of the HHs with education < bachelor's degree level
Housing condition	Wall deprived	MDI 2007	% of housing with substandard wall materials (mud, wood, thatch, stones, and their combinations)
	Floor deprived	MDI 2007	% of housing with sub-standard floors (mud, bamboo reed, and their combinations)
	Ceiling deprived	MDI 2007	% of housing without ceiling
	Aged house	MDI 2007	% of housing age \geq 20 years
	Deprived housing facilities	MDI 2007	% of housing-deprived of three facilities (radio, TV, house phone). For example, 0% deprived means HHs has three facilities, and 100% deprived means HHs have zero (no) facilities.
Health	Over crowdedness	MDI 2007	% of HHs over-crowdedness \geq 2.5 person/room
	Population density	MDI 2007	2007 census population per kebele area in hectares)
Services and infrastructure	Own piped water-deprived	MDI 2007	% of housing using shared pipe tab, protected/unprotected well, river/lake/pond
	Sanitation-deprived	MDI 2007	% of housing with either a pit latrine shared by one or more HHs or no toilet at all
	Waste disposal-deprived	MDI 2007	% of housing that was not using public dump/private house collection
	Modern cooking-	MDI 2007	% of housing which was not using gas and electricity

	deprived		for cooking
	Electric light-deprived	MDI 2007	% of housing that was not using electricity for lighting
	Bathing facility proportion	MDI 2007	% of housing with no bath facilities
	Kitchen-deprived	MDI 2007	% of housing with no specific kitchen room
Tenure	Private tenure owner deprivations	MDI 2007	% of housing whose occupant is not the owner of the house (the occupant is a renter or rent-free)
Social Vulnerability	Disabled population	MDI 2007	% of disability per population
	Migrant population	MDI 2007	% of migrants per population
	Widowed/divorced FHHs	MDI 2007	% of FHHs with marital status widowed or divorced
	Unemployment	MDI 2007	% of the unemployed population with age ≥ 10 years and < 65 years per economically active population (10–64 age group based on Ethiopian census)
	Old dependency rate	MDI 2007	% of the population ≥ 65 years old per productive force population (15–64 age group)
	Young dependency rate	MDI 2007	% of the population with 0–14 years old per productive force population (15–64 age group)
Factors MDI 2016	Indicators/Variables	MDI Year	Indicator Description
Income	2016 Income per AE	MDI 2016	HH income per adult equivalent (AE) per month for 2016. AE indicates poverty measure is adjusted for the difference in the calorie requirements of different HH members (for age and gender of adult members).
Education	Illiterate HHs	MDI 2016	% HHs with illiterate educational status
	Non-degree HHs	MDI 2016	% HHs not having degree and above education status
Employment	Self-employed HHs	MDI 2016	% HHs employed in self-employed formal business.
	Unemployed HHs	MDI 2016	% HHs unemployed from economically active age group (10–64)
Social vulnerability	FHHs widowed/Divorced	MDI 2016	% FHHs with widowed/divorced marital status
	Older HHs	MDI 2016	% HHs with age 65 and above
Overcrowding	Population density	MDI 2016	2016 projected population per kebele area in hectares
	Building density	MDI 2016	Building footprint area percentage per kebele (based on 2010 15 cm aerial photograph)

Environment	Green per capita	MDI 2016	Green area coverage in meter square per 1000 population of kebele (based on existing land use prepared for the 2017 structure plan of Addis Ababa)
Infrastructure	Road per capita	MDI 2016	Road area coverage in hectares per 1000 population of kebele (based on existing road area for the 2017 structure plan of Addis Ababa)

3.3.3. Data types for specific objective 3

The data types for morphological aspects are organized and described based on the data used for ontology levels of environment, settlement, and object, as indicated below. The environment level used the dependent and independent variables described in Table 3 for logistic regression analysis. The settlement and object-level data types are indicated in Table 4. Table for data types are used for characterizing the settlement and object levels based on the concept of slum ontology. Table 4 also described layers for quantifying the extracted settlement or object area extent and growth trends.

Table 3 the data type used for the level of environment and settlement for logistic regression analysis used.

<i>Code</i>	<i>Description</i>
Dependent variable	
Sett_bin2010	1= The delineated settlement is Informal for 2010. 0 = The delineated settlement is Formal for 2010.
Sett_bin2022	1= The delineated settlement is Informal for 2022. 0 = The delineated settlement is Formal for 2022.
Independent variables	
Rive_Pro2010	The proportion of the 2010 settlement area that lies within 50-meter of the river
Rive_Pro2022	The proportion of the 2022 settlement area that lies within 50-meter of the river
Slop_Pro2010	The proportion of the 2010 settlement area with a slope $\geq 15\%$
Slop_Pro2022	The proportion of the 2022 settlement area with a slope $\geq 15\%$
Trve_Pro2013	The proportion of settlement area with land use allotted for trees and vegetation based on 2013 LULC
Trve_Pro2021	The proportion of settlement area with land use allotted for trees and vegetation based on 2021 LULC
Grop_Pro2013	The proportion of settlement area that the land use allotted for green, bare land, or open spaces based on 2013 LULC
Grop_Pro2021	The proportion of settlement area that the land use allotted for green, bare land, or open spaces based on 2021 LULC
Crop_Pro2013	The proportion of settlement area allotted for crops based on 2013 LULC

Crop_Pro2021	The proportion of settlement area allotted for crops based on 2021 LULC
Buil_Pro2013	The proportion of settlement area allotted for built-up based on 2013 LULC
Buil_Pro2021	The proportion of settlement area allotted for built-up based on 2021 LULC
Pop_Dens 2010	1= Population density above and equal to 12000 people per square kilometer for 2010 and 0= population density less than 12000 people per square kilometer for 2010.
Pop_Dens2020	1= Population density above and equal to 12000 people per square kilometer for 2020 and 0= population density less than 12000 people per square kilometer for 2020.
<p>Note:</p> <p>1. The settlement area means settlement delineated based on November 2010 aerial photograph and 2022 google image.</p> <p>2. The population is based on 2010 and 2020 WorldPop gridded data (100m by 100 meters) while the area is based on the delineation from 2010 aerial photograph and 2022 google image.</p>	

Table 4 the data type used for settlement and object level.

Conceptual level	Area extent	Level	Information types
Informal area 2010 (Aerial photograph 2010)	City wide	Settlement	Deprived area for 2010
Informal area 2022 (Google image)	City wide	Settlement	Deprived area for 2022
Informal population 2010	City wide	Settlement	Informal Population proportion for 2010
Informal population 2020	City wide	Settlement	Informal Population proportion for 2020
Formal Population 2010	City wide	Settlement	Formal Population 2010
Formal Population 2020	City wide	Settlement	Formal Population 2020
Population points data distribution pattern 2010	City wide	Settlement	Population point data derived from world pop gridded data from 2010
Population points data distribution pattern 2020	City wide	Settlement	Population point data derived from world pop gridded data for 2020
Object (building) level 1 2010	Addis ketema sub-city wide	Object	Impervious (building) and other surfaces area inner-city slum
Object (building) level 2 2010	Bole Sub-city Kebele 11	Object	Impervious (building) and other surfaces area intermediate Formal settlement
Object (building)	Akaki Kaliti sub	Object	Impervious (building) and other surfaces

level 3 2010	city Kebele 07		area peri-urban Informal settlement
Object (building) level 4 2010	Kolfe Keranyo sub-city Kebele 02	Object	Impervious (building) and other surfaces area Formal settlement expansion area

3.4. Sources of Data

3.4.1. Sources of data for specific objective-1

The research uses primary sources of data collected by researchers as first-hand information. Firsthand information is collected using closed-ended questionnaires, open-ended questionnaires (key informant interviews), and individual case studies with vulnerable sub-groups. The secondary sources of information were the kebele rental housing information and cadaster base map information provided by the Addis Ketema Wereda 07 administration and the Addis Ababa city administration, respectively. Once collected, primary data sources were validated by secondary sources, enhancing the quality of firsthand survey information with data collected for the whole area obtained from secondary information.

3.4.2. Sources of data for specific objective 2

The study uses primary and secondary sources of information. The original source is the Ethiopian Census of 2007 and the Household Expenditure and Socioeconomic Survey for 2015–16. The above data were obtained in a row data entry form from CSA. The row data was obtained at household and population levels. This row of data from CSA was statistically aggregated and summarized, and variables were combined to measure the concept or construct stated in deductive theoretical frameworks. The study uses secondary information sources, including one variable (population) extracted from the published document of the CSA (2013a), as well as the published information of the CSA, for the background information. The study also used secondary information from the digitized spatial data regarding roads, buildings, and green areas obtained from the Addis Ababa city administration. The road and green areas were extracted based on existing land use used for the 2017 structure plan, while the building is the cadaster building extracted from an aerial photograph of 2010. The research integrates the primary and secondary source information to perform multivariate analysis, refine indicators and factors, and construct a composite index for deprivations.

3.4.3. Sources of data for specific objective 3

Satellite or aerial imagery can be described as direct measurement or a primary source (ESRI, 2023) if it is not converted to vector or provided in classified or statistical analysis form. The primary data source includes the row data from the aerial photograph of 2010; the Google image of 2022; and the Landsat 8 image of 2013. The secondary sources include the ESRI 2021 LULC, the European Space Agency global 30m digital elevation model, and world population gridded data for 2010 and 2020 of 100 by 100 meters. The data sources included the VHR image from an aerial photograph acquired on November 2010 (Zein, Hartfiel, Berisso, 2012) and a real time Google image of 2022. The study also used 30-meter multiband imagery from Landsat 8, launched on February 11, 2013. The study also used the 2021 ESRI Sentinel-2 10m LULC extracted by deep learning (ESRI, 2022b). The study used WorldPop gridded population data (2010 and 2020) for 2010 and 2020 estimated at 100-meter intervals by the cooperation's of the University of Southampton, the University of Louisville, the Center for International Earth Science Information Network, and Columbia University. The study also uses the Copernicus global digital elevation model (30-meter interval) from open topography (European Space Agency, 2021) for deriving slope and extracting rivers with stream orders greater than 5 by the hydrological and slope analysis model in Arcgis Pro.

3.5. Sample Design

3.5.1. Multistage sampling design for cross-sectional survey of 2018

The research selected two case study areas from inner-city slums and peri-urban areas of Addis Ababa based on two slum model dichotomies (Eckstein, 1990; Stoke, 1962). The study also used Burgess concentric model to select inner-city slum impoverished areas near CBD reflecting transitional zone.

Despite the slum theoretical model being debatable in a different context, the consensus is the dichotomous nature of slum settlement for selecting the two case study areas. Accordingly, the research followed multistage sampling. Primarily, the study conducted a series of purposive sampling to arrive at targeted area depicting theoretical and empirical lenses. Then, based on the ultimate targeted area with finite population, the research conducted systematic random sample survey. The selected areas for sample survey were Addis-Ketema sub-city Wereda-07 inner-city

slum (the inner-city slum) and Kolfe-Keranyo sub-city Wereda-03 peri-urban Informal settlement (the 'peri urban'). The systematic random sampling size was determined by Yamane's (1967) formula for the finite population with degree of confidence levels as follows:

$$n = \frac{N}{1 + N(e)^2} \quad \text{Equation (1)}$$

Where, n= sample size required, N = Number of Household in the population, e = level of significance varies based on research conditions.

The percentage of the sample taken from the finite household size also considered the homogeneity and heterogeneity of the dwellers socio-economic status. The systematic random sampling procedures selected the targeted HHs that represents the total HHs at regular intervals, based on preliminary information. The face-to-face interview with the randomly selected households, based on the sample survey formula for a finite population, enhances the external validity of the research. Then, considering the theoretical lens coupled with purposive sampling methodology, two areas were screened for further conducting systematic random sampling. To refine areas that at least satisfy the deductive theoretical frameworks coupled with the bottom-up approach, an in-depth interview was conducted with sub-city and wereda officials regarding which area fits the requirements of the study, the size of the population, the dwellers' livelihoods, socio-economic status, and the renewal or intact nature of the settlement area. Then, systematic random sampling was planned based on the finite population and households estimated by the census, as well as the population and household estimates by Wereda administration officials. The details of multistage sampling procedures of purposive and systematic as well as the way arriving at sample size is as elaborated below for inner-city slum and peri urban.

3.5.1.1. Multistage sample design for the Inner-city slum

The study applied multi-stage sampling. In the first stage of sampling, CBD areas were assessed in Addis Ababa to find low-income areas near the old CBD of the inner-city slum that depicted the socio-spatial segregation theoretical models. The slum theoretical model of Stoke (1962) claimed the inner-city slum as “*sum of despair*” and a concentration area of deprivations. Therefore, there were four old centers in Addis Ababa situated in the inner-city areas: the National Theatre, Arat Kilo, Piazza, and Merkato. The inner-city slum neighborhoods were

characterized by old, deteriorated structures and a concentration of single buildings with low-income groups (ORAAMP, 2001).

Nonetheless, in the second stage of sampling, from the four old centers, the Merkato area (in Addis Ketema sub-city) was selected because it was the main receptor area for recent migrants and low-income concentration areas near the old CBD reflecting the transitional zone of Burgess's concentric theoretical model.

In the third stage of sampling, the Addis Ketema sub-city was selected purposively from Addis Ababa due to its location near the old CBD, the main transport hub, and a large market. Then, in the fourth stage of sampling, the researchers selected purposively the Wereda-07 inner-city slum from the ten weredas' by consulting with Addis-Ketema sub-city officials (D. Mekonnen, personal communication, October 24, 2018). The researcher reached consensus with the sub-city officials to select an intact area from the sub-city, not yet affected by urban renewal interventions. Then, the researcher selected Wereda 07 supported by preliminary field verifications fulfilling the prescribed criteria. The feature of wereda 07 inner-city slum houses were aged, dilapidated, overcrowded, and degenerating services, near the old CBD and transport hub, and an intact settlement (not affected by renewal). The projected population and HHs size for Addis Ketema Wereda 07 in 2018 were 32,646 and 6801, respectively. The projection considered the base population of the wereda according to CSA, 2007, and the 3% annual growth rate of Addis Ababa in 2017 (CSA, 2013a). The envisaged systematic random sample survey was 378 HHs, from the overall HHs size of 6810 HHs for Wereda 07, at the 0.05 level of significance. Yet, the actual data entry was 404 HHs tagged with GPS coordinates, which suffices for the survey considering the relative heterogeneity and dense nature of the area. Accordingly, every 17th HHs(16.8 HHs) was questioned and surveyed by data collectors. The determined sample size is computed as indicated below.

$$n = \frac{N}{1 + N(e^2)} = \frac{6810}{1 + 6810(0.05^2)} = \frac{6810}{1 + 17.025} = 378 \text{ HHs}$$

3.5.1.2. Multistage sample design for peri-urban

Based on the dichotomous theoretical model of Stoke (1962), squatter or peri urban informal settlement was characterized by ‘*slum of hope*’. Thus, in the first stage of sampling, peri-urban informal settlements were targeted reflecting peri urban informal settlement in Addis Ababa. Then, to filter consolidated Informal settlements, the regularized building structure of Addis Ababa (based on a satellite image of 2005) was overlaid on a recent google image of 2018. In the second stage, from peri-urban areas, Kolfe-Keranyo and Bole sub-city were identified as the main informal settlement trajectory areas. Yet, the trends of settlement mushrooming were relatively increasing for Kolfe-Keranyo, based on the filtered spontaneous settlements and the further verification of the previous research of Minwuyelet (2005).

In the third stage, Kolfe Keranyo was targeted, and consultation made with the Kolfe keranyo Sub-city Transitional Land Administration Project office to select targeted wereda for conducting survey on spontaneous settlements flourished after regularization. The Transitional Land Administration Project Office informed that portion of Wereda 03, in hilly areas, was one of the weredas’ with consolidated informal settlement (G. Gebreegziabhere, personal communication, June 12, 2018).

Then, in the fourth stage, based on information from the building permit office of wereda 03, the informal settlement jurisdiction part of wereda 03 was delineated differentiating from formal neighborhood quarter of wereda 03. The building permit office of wereda 07 further informed that the total HHs in the delineated area was 2500. Accordingly, the targeted HHs for the systematic random sample survey was 250 at a 0.06 level of significance. Yet, the performed data entry was 252 HHs, which was a sufficient sample considering the relative homogeneity of the area. Accordingly, every 10th HHs was questioned and surveyed by data collectors.

$$n = \frac{N}{1 + N(e^2)} = \frac{2500}{1 + 2500(0.06^2)} = \frac{2500}{10} = 250 \text{ HHs}$$

3.5.2. Convenient sampling design for object-based urban morphology deprivation analysis

For urban morphology aspects of deprivations, the environment and settlement level of morphological aspects of deprivations were studied at city wide scale while the object based random tree classification was performed on four selected areas based on convenient probability sampling. Convenient sampling is a non-probability sampling where units are selected for inclusion in the sample because they are the easiest for the researcher to access which can be due to geographic proximity, availability at a given time or willingness to participate in the research (Nikolopoulou, 2022b). The researcher selected four areas: two from informal and two from formal areas based on prior knowledge of the settlement. The selected four settlements based on convenient sampling were Addis Ketema sub-city inner-city slum, Bole sub-city Kebele 11, Akaki Kaliti sub-city Kebele 07, and kolfe Keranyo sub-city Kebele 02.

3.6. Method of Data Collection

3.6.1. Method of data collection for specific objective-1

For quantitative research, the data collectors were four (4) for the inner-city slum and two (2) for the peri urban. The data collectors (minimum bachelor's degree) took orientation on questionnaires, and the questionnaires were tested and updated on the pilot area before full scale-up. The data collectors filled the questionnaires by face-to-face interview with each household (HH) and performing physical validation and measurement. The SPSS analysis filtered the vulnerable sub-groups from the collected quantitative data. The researcher validated data collectors during the field survey through sample field checks and revisiting some areas for bridging the gaps on unfilled questionnaires. Each enumerator filled the GPS coordinates of the HH housing location in the close-ended questionnaire before conducting face to face interview with households and physical validation. The quantitative questionnaires consisted of sections of area and location identification (6 questions), HHs basic characteristics for HHs (26 questions) & housing (14 questions), service and infrastructure (9–10 questions), regulatory and perception related (18 questions). The question for service and infrastructure is 9 for the inner-city slum and 10 for peri urban (see annex 1 and 2). The individuals' case study enabled finding indepth and real-life situations of vulnerable sub-groups. The targeted participants for the individual case study were nine purposively selected persons (chronically poor women, poor women renter, two

tenure right dispossessed men, tenure dispossessed women vulnerable to poor sanitation, CBO member widowed women, CBO member men, and two women vulnerable to poor infrastructure). The researcher made an in-depth key-informant interview with sub-city and Wereda local administrations on livelihood aspects of an institution, capability, risks, safety, and other issues. Key informant interviews were executed for twelve (12) government staff from each of peri-urban and the inner-city slum, respectively. The total interviewed officials from wereda and sub-city were twenty four. The Key informant interview purpose was to collect information on the remaining aspects of the study regarding the role of institutions in access and control of asset by vulnerable subgroups, the practise of mobilizing individual and collective capability, food security situation, assesment of risks and safety. The primary data collected through quantiative and qualitative method was further enriched with secondary information obtained from cadaster base map in autocad format and rental house information collected from Addis ketema wereda 07 office(for inner-city slum). See Annex-1 and 2 for close ended questionnaire used for household survey and Annex-3 for key informant interview.

3.6.2. Method of data collection for specific objective 2

CSA is the official data provider for monitoring and evaluation tools in Ethiopia (MOFED, 2013; ENPC, 2017). Ethiopia conducted censuses in 1984, 1994, and 2007. The government indefinitely postponed the 2018 census due to social unrest. The 2016 CSA HH expenditure survey covered 93 kebeles out of 99 kebeles in Addis Ababa. The requisite data for the remaining six kebeles were estimated based on the average values of the surveyed kebeles that surrounded them. The data for the 2007 census and the 2015/16 household expenditure survey were collected by the CSA with its own rigorous census and survey sampling strategies, respectively. In this research case, the census gives information about the population and housing characteristics of Addis Ababa. The 2015-16 household expenditure survey gave information regarding expenditure and socio-economic data for 3832 surveyed HHs. The MDI 2007 used the population and housing census for 99 kebeles of Addis Ababa. The MDI 2016 used the 2016 CSA HH expenditure and socio-economic survey, the 2016 CSA population projection (CSA, 2013a), the base map of the 2017 Addis Ababa structure plan, and the building footprints of the 2011 Addis Ababa aerial photograph.

3.6.3. Method of data collection for specific objective 3

The 2021 LULC categories were extracted by ESRI using a deep learning algorithm from a sentinel image of 10 m resolution. The ESRI has already verified the 2021 LULC from a massive training dataset of billions of human-labeled image pixels (ESRI, 2022b), proving that there is no need to compute errors of omission and commission. The ESRI 2021 LULC was used as an independent variable to predict the deprived areas of 2022. The study extracted LULC for 2013 from the raw image of Landsat 8, which was then classified using a pixel based SVM algorithm. The study did not use the old version of Landsat 7 before 2013 due to many strips and noise-degrading the quality of classification. The environmental features extracted from Land Sat 8 were validated by taking 500 samples from the 2010 aerial photograph and computing the confusion matrix. The 2013 LULC was used as the independent variable for predicting 2010 deprived areas. The slope and river layers are a product of the downloaded 30-meter Copernicus digital elevation model (DEM) (European Space Agency, 2021). The rivers for Addis Ababa were extracted using the Strahler method hydrological analysis in ArcGIS Pro, considering the six and above stream orders from the total nine stream orders. The slopes were also derived from 30m DEMs, classifying slopes above 15% as areas costly for residential development. The research also integrated 100-metre by 100-metre world population gridded data for estimating the population of deprived areas for 2010 and 2020 (Worldpop 2010 and 2020). The gridded population data considered built-up and residential areas for a realistic interpolation of population density. Yet, based on world population gridded data, the Addis Ababa population size for 2020 is underestimated relative to the census official figure, which needs further research to confidentially predict the informal settlement population for Addis Ababa. The data sources included the VHR image from an aerial photograph acquired on November 2010 (Zein, Hartfiel, Berisso, 2012) and a real-time Google image of 2022. In addition, the study used for comparison of settlement evolution from infancy to the consolidation of the quick bird image of Addis Ababa acquired on January 4, 2009 (based on the image header file) but it should be noted that this image was not used for analysis. Population gridded data was developed by WorldPop in geotiff format, making a population estimate at a 100-meter by 100-meter grid cell using the RF algorithm, and the units are the number of people per grid cell (Bondarenko, Kerr, Sorichetta, Tatem, 2020). Even if the assumption considered the built-up and settled area, the gridded population data is constrained by the fact that populations are not evenly distributed in space

(Thomson et al., 2021). WorldPop population estimates were made for all land areas with the assumption that a small percentage of people were predicted to live in deserts, forests, and an unsettled grid cell (Loyd, Chamberlain, Kerr, Yetman, Pistolesi, Stevens, Gaughan, Nieves, Hornby, & MacManus, 2019). The deprived areas (informal settlements) were delineated using VHR images of an aerial photograph from 2010 and a real-time Google image from 2022. The minimum settlement mapping unit ranges from 100m² for 2022 and 200m² for 2010 for spontaneous and alienated settlement. The interpretation elements for the manual delineation of formal and informal settlements follow the interpretation elements specified in Table 3 at the settlement level. The classified deprived and less deprived areas from VHR are verified by the 113 sampled points for each sub-city and the corresponding photographs and ancillary descriptions (Annex 4). Furthermore, the ground verification points are chosen with the assumption that the sampled areas will still exist in 2010 and 2022. The ground-verification points are filled in a format, tagged with WGS x and y coordinates, with the relative locations of the points, settlement descriptions, and road furnishing materials. The modalities of the identified informal and formal settlements and the interpretation elements for identifying deprived areas and objects at settlement and environment levels are illustrated on table 5 and the object levels are illustrated in table 6. The different morphology of settlements for informal, inner-city slum, peri-urban authorized colonies settlement evolution, the regularized informal and formal settlement characteristics are presented starting from figure 7 to 10.

Table 5 the environment and settlement level indicators based on the concept of slum ontology, literature review and Ethiopian context.

Indicator	Interpretation	Environment level: Informal(deprived) and Formal (less deprived area)
Location	Neighborhood Location	Informal settlement: along hazardous sites (polluted rivers, flood areas, close to or within high-tension lines, steep slopes, grain hulls, waste disposal sites, polluting industries). Peri-urban informal settlements lie near farmland. Some formal settlements are seen on steep slopes in Addis Ababa, especially in the Yeka sub city.
Location	Neighborhood Location	It is close to employment opportunities and close to the CBD, typically for the inner-city slums of Addis Ababa, while it is the opposite for peri-urban informal settlements. Formal settlements were dispersed mainly in the intermediate areas of Addis Ababa.
proportion	Green area proportion	There is less green area in Addis Ababa's inner-city slum, while grass and tree coverage is high in informal settlements, peri-urban areas, and formal settlements.
	Crop area proportion	There is less Crop area in the inner-city slum, while the crop area is high in peri-urban informal settlement and formal settlements.
Indicator	Interpretation	Settlement level: Informal(deprived) and Formal (less deprived area)
Shape	Building and road Shape	The informal settlements' layout and roads have an irregular shape and organic layout, while the formal settlements have a regular, inorganic layout. The regularized informal settlements have a mix of organic and inorganic layouts.
Density	Built-up Density	Built-up areas are denser in the inner-city slum areas, with less space between houses- clumped together in space. Smaller building sizes and more open spaces characterize peri-urban informal settlements. The formal settlements have regular spacing between medium-to-large buildings. The regularized informal settlements have a mix of regular and irregular spaces between the buildings. In 2018, according to the Kolfe Keranyo peri-urban area survey, the median built-up per plot was 21.4%.
	Land use heterogeneity	Land use heterogeneity is more prevalent in older and denser slum settlements, whereas peri-urban land use is more homogeneous. In the inner-city slum of Addis Ababa, in addition to the pure land use used for services, infrastructure, and other functions, 18.1 percent of the HH used their homes for manufacturing, services, and trade. 3.27% of HH in peri-urban informal settlements used their homes for manufacturing, services, and trade activities. Formal settlements have diverse land uses as stated in the statutory plan. The above empirical figure is based on our survey conducted in Addis Ketema inner-city slum and Peri-urban informal settlement of Kolfe Keranyo in Addis Ababa.
<p>Author-based sources: FDRE, 2009; Sliuzas & Kuffer, 2008; Kohli et al., 2012a; Wurm, M., Stark, T., Zhu, X. X., Weigand, M., & Taubenbock, H. (2019); Kuffer et al., 2020; Arif, Ahsan, Devisch, Schoonjans, 2022). Analysis sources: own visual image interpretation of Addis Ababa, ground verification and the 2018 survey on informal settlements of Addis Ketema and Peri-urban Kolfe Keranyo</p>		

Table 6 the object level indicators based on the concept of slum ontology, literature review and Ethiopian context.

Indicator	Interpretation element	Informal(deprived) and Formal (less deprived)
Building	Shape	The building shape is dominantly irregular for informal settlements and regular for formal settlements, and the irregularity is pronounced in slum areas
	Color	The color of the roof is an expansive dark brown CIS (Corrugated Iron Sheet) interspersed with small spots of light blue and white in an inner-city slum of Addis Ababa, indicating the replacement of new CIS in place of rusting ones. Furthermore, small, light blue, and white roofs are common features in intermediate and peri-urban informal settlement areas. The formal settlement consists of roof colors (brown, black, blue, red, white, and green).
	Size	The average building size is small for informal settlements. Based on the case study survey areas of Addis Ababa in 2018, the average building size is 33 m ² for the inner-city slum of Addis Ketema sub-city and 38 m ² for the Kolfe Ketanyo peri-urban areas. The building size for formal settlements is larger than for informal settlements. Based on a delineation from aerial photographs taken in 2011, the average building sizes for the informal and formal areas were 39.7 m ² and 54.3 m ² , respectively.
	Orientation	The building orientation is variable for informal settlements and follows a similar pattern for formal settlements.
	Material	The wall material is mud with thatch or mud mixed with other materials for informal settlement areas, while it is a mix of sub-standard and standard materials for regularized informal settlement. The building materials are mainly those allowed in accordance with Ethiopian Building Proclamation No. 4/2009: standard hollow blocks, bricks, and others for formal settlements (Federal Democratic Republic of Ethiopia, 2009).
	Height	For informal settlements, building heights are generally low, whereas for formal settlements, building heights range from villas to low- and medium-rise buildings (condominiums, apartments, and private residences).
Access Road	Shape	The road shape is predominantly irregular, with narrow road networks as well as dead-end streets for informal settlements. The road shape is a mix of organic and inorganic for regularized informal settlements. The road shape is regular for formal settlements.
	Texture	The road is unpaved for peri-urban informal settlements. The road is paved for regularized informal settlements, formal settlements, and inner-city slum areas.
	Width	The road width is irregular, interspersed with dead-end streets for informal settlements. Paved collector roads for informal settlements in the center and intermediate. A mix of regular and irregular shapes for regularized informal settlements The road width is regular and allows vehicular access for formal settlements.
<p>Author-based sources: FDRE, 2009; Sliuzas & Kuffer, 2008; Kohli et al., 2012a; Wurm, M., Stark, T., Zhu, X. X., Weigand, M., & Taubenbock, H. (2019); Kuffer et al., 2020; Arif, Ahsan, Devisch, Schoonjans, 2022). Analysis sources: own visual image interpretation of Addis Ababa, ground verification and the 2018 survey on informal settlements of Addis Ketema and Peri-urban Kolfe Keranyo</p>		



The color of the roof ranges from brown to blueish white. The commonest characteristics are high roof density, no setback from the property line, small building size, variable building orientation, and less green/open space. Regular collector roads, less access to local roads, and a lack of right of way for some dwellers.

Figure 7 characterizing the deprived area or object based on Addis Ketema sub-city inner-city slum of Addis Ababa.



The color of the roof ranges from white to bluish white. The built-up/roof density varies from low and sporadic at the inception stage (on the left) to consolidated at a later stage of settlement evolution (on the right). At an earlier stage of development, a small building size, which was surrounded by an irregular and large fenced plot. Most parts of the road are unpaved and irregular. There is variable building orientation. The settlements are located along previous farmland or physically hazardous sites near the sides of hills and river valleys.

Figure 8 Characterizing settlement evolution from infancy to consolidation of the same Akakai Kaliti peri-urban settlement area of Addis Ababa: based on quick bird image of 2009 and google image of 2010.



The dominant roof color is white (bluish white), brown, and red. The settlement is interspersed with a mix of substandard and standard buildings. The roof density is by far lower than in the inner-city slum area. The distribution of vegetation and open space is haphazard. Building orientation does not follow any pattern. The building's shape and size are variable. The road is paved and furnished but depicts an irregular pattern as it is upgraded based on existing configuration. The field reconnaissance verified that reasonable percentages of the substandard houses have gradually improved to standard houses through the transactions of houses after regularization and the resultant gentrification.

Figure 9 Characterizing regularized informal settlement type based on Yeka Subcity area of Addis Ababa



The formal settlement has inorganic building and road layouts in general due to the influence of statutory plan. Planned green and open space is also a typical nature of formal settlement. The shape of the building is regular with different roof colors of silver, medium brown, light brown, and red color.

Figure 10 Formal settlement area and buildings based on Bole sub city area of Addis Ababa

3.7. Method of Data Analysis

3.7.1. Method of data analysis for specific objective 1

The software used for data entry was IBM SPSS Statistics 20, while data analysis was done using SPSS Statistics 20 and ArcGIS 10.4.1. The tests used in the research were the chi-square test (χ^2), OWAUV, PPMC, and SRC. In the chi-square test, insignificant associations were not included ($p > 0.05$). The systematic random sampling strategy allows for generalizing from inferential statistics for the defined jurisdiction and population. The study triangulates the findings of inferential statistics with descriptive statistics and qualitative analysis (a key informant interview and an individual case study) for making sound deductions by triangulating different information. The GIS software analyzed spatial data (services, infrastructure, and topography) and integrated it with the database of the questionnaires in SPSS (each HH tagged with GPS x and y coordinates).

The study uses chi-square, a non-parametric measure that relates two nominal variables supported by hypotheses and significance levels. The research uses OWAUV, using Welch statistics, for the comparison of three or more groups with unequal variance to test whether the difference in the mean of each group is statistically significant. The research performs correlation for ratio variables using PPMC and for ordinal or rank measurement level variables using SRC. The key informant interview analyzed the capability, risk, safety, and institutional aspects of livelihood capital assets and validated some aspects of the quantitative data. The quantitative analysis of livelihood capital asset deprivations coupled with the key informant interview analysis of capability, institutional, risk, and safety aspects helped to emanate strategies for ABS interventions for asset accession, valuation, and transformation. In addition, some of the in-depth aspects explored by key informant interviews and individual case studies validated the quantitative findings and the depth of deprivations among sub-groups. The income per AE considers the different calorie requirements of adults and children.

According to the authors (Shinns & Lyne, 2002), $AE = (No. Adult + 0.5 \times No. Children)^{0.9}$

The absolute poverty line of Ethiopia for 2015/16 was less than birr 7184 per year per AE, or (< 599 birr / month (M)/ AE).

3.7.2. Method of data analysis for specific objective 2

PCA is an orthogonal transformation of a system of variables x_1, x_2, \dots, x_n , into y_1, y_2, \dots, y_p . It has a mathematical form:

$$x_i = b_{i1}y_1 + b_{i2}y_2 + b_{i3}y_3 + \dots + b_{ik}y_k$$

$$i = 1, 2, \dots, n$$

Equation (2)

$$k = 1, 2, \dots, p,$$

The number of empirical variables is equal to the number of components ($n = p$), and the total variance of the variable x_i is equal to the component variance y_k (Chojnicki & Czyz, 1976). The PCA varimax rotation maximized the sum of the variances of the square loadings. Because of the rotation, each component has a small number of higher loadings, simplifying items' loadings by removing the middle ground (Herve, 2003). Components with an Eigenvalue of greater than one indicated significant components, which explained most of the variance in the original data set. Component loading is the correlation between a specific observed variable and a specific component. Communality is the sum of all the squared factor loadings, and it is the same as r^2 in regression analysis (Beaumont, 2012). The direction and strength of the relationships between the component's indicators, with high loading scores, were taken into consideration when naming the components.

There are two MDI construction scenarios. Regarding the first scenario, the first component that loaded highly on many variables was a measure of multiple deprivations (Bernard, 2011). The second scenario, the one used in this research, first developed NSMDI (non-standardized MDI), based on the percent of variance explained by components with eigenvalues > 1 , the total variance explained by considered components for the MDI, and the component score for each unit (Kebele) (Vijaya, 2010). Secondly, the standardized MDI was developed by standardizing the NSMDI with a linear function between the absolute highest and lowest score (Vijaya, 2010; Lu, 2003). Accordingly, the MDI summarizes complex dimensions of deprivation into a single, easy-to-use numeric representation (Vijaya, 2010; Mirjam, Alastair, Maria, Travassos, Ruth, 2020). The NSMDI formula is specified below.

$$NSMDI_t = \left(\frac{c1}{cs}\right) \times (f1) + \left(\frac{c2}{cs}\right) \times (f2) + \left(\frac{c3}{cs}\right) \times (f3) + \dots + \left(\frac{cn}{cs}\right) \times (fn) \quad \text{Equation (3)}$$

The $NSMDI_t$ indicates NSMDI at time t, and t designates the agreed-upon MDI year setting. The code “ci” indicates the variance explained by component with eigen value > 1. The designation code, c1 up to cn, denotes the variance explained by each component with an eigenvalue > 1, where ci ranges from c1 to cn. The designation “fi” means factor or component score of each Wereda. Thus, “fi” ranges from f1 to fn. cs is the sum of the variance explained by the components (c1 to cn) with eigen value > 1. The MDI formula is specified below.

$$MDI_t = \left| \frac{(NSC - NLV)}{(NHV - NLV)} \right| \times 100 \quad \text{Equation (4)}$$

The MDI_t designates MDI at time t (year). The designation NSC denotes the $NSMDI_t$ coefficient value of each kebele unit of Addis Ababa. NLV denotes a low coefficient value for $NSMDI_t$, while NHV denotes a high coefficient value of $NSMDI_t$. The standardized MDI_t ranged from 0% (no deprivation) to 100% (maximum deprivation). The MDI is classified into quintiles using an equal-interval approach. The MDI ranged from a standardized score of 0% to 25% (low-deprived, or LD), 25–50% (deprived, or DE), 50–75% (high-deprived, or HD), and 75–100% (very high-deprived, or VHD). “Most deprived” comprised the HD and VHD.

ArcGIS software converted the MDI polygon layers to point layers and ran interpolation on the point layers using the Inverse Distance Weighting tool. The profile graph was derived in ArcGIS using the interpolated raster as the background layer. The profile graph modeled the spatial trend in deprivation score and population density as distance increased from the CBD to the periphery. The profile graph plotted the 20 km cross-section spanning from the old CBD towards the outskirts of the Akaki Kaliti sub-city of Addis Ababa. The profile graph pointed from the CBD to the Akakai Kaliti sub-city periphery (rather than other city fringe areas), as the Akaki Kaliti sub-city had peri-urban informal settlements before the 2007 census.

“Moran’s, I” is an index used to indicate the degree of spatial polarization of deprivations for this study. When similar standardized MDI component values cluster together, the index is positive,

while the index is negative when dissimilar values cluster together. The MDI component value close to “0” indicates no spatial autocorrelation.” Moran’s, “I” give the overall spatial autocorrelation, but it is not useful to distinguish the variation in local spatial patterns of the MDI components (ESRI, 2022a). Moran’s I statistic (I) for spatial autocorrelation and Z_I score (Z_I) for the statistics (ESRI, 2022a) are given as follows:

$$I = \frac{n \sum_{i=1}^n \sum_{j=1}^n w_{i,j} z_i z_j}{s_o \sum_{i=1}^n z_i^2} \quad S_o = \sum_{i=1}^n \sum_{j=1}^n w_{i,j}$$

$$Z_I = \frac{I - E[I]}{\sqrt{v[I]}} \quad \text{Where: } E[I] = -1/(n-1) \quad \text{Equation (5)}$$

$$v(I) = E(I^2) - E(I)^2$$

Based on Moran’s I statistics (I), z_i is the x-component value of the kebele “i” deviation from the mean value ($x_i - \bar{x}$). $w_{i,j}$ is the spatial weight between kebeles “i” and “j”, and n is the total number of kebeles (neighborhood units). s_o is the aggregate of all spatial weights. When the p-value is statistically significant, for the component with a positive or negative z-score, you may reject the null hypothesis.

LISA is used to assess local hotspots and the impact of individual locations on the magnitude of “Moran’s I” and to identify outliers (Anselin, 1995). A positive value for LISA indicates spatial clustering of similar values (either high or low values), and a negative value indicates spatial clustering of dissimilar values. In this paper, LISA examines the local-specific pattern of a given MDI component value that most strongly contributes to spatial inequality and poverty polarization. GeoDa software computed LISA and Moran’s I spatial statistics, considering the weight given for each “kebele,” or neighborhood unit, using queen contiguity weight. The LISA formula is specified as indicated below, based on Anselin (1995).

$$I_i = z_i \sum_j w_{ij} z_j, \quad \text{Equation (6)}$$

Analogous to the global Moran’s I, the observation z_i , and z_j are in deviation from the mean. The summation over j is such that only neighboring values $j \in J_i$ are included. w_{ij} denotes weights,

which may be in the row-standardized form or not. The weight w_{ij} is, by convention, equal to “0” (Anselin, 1995; Chen, 2022). A high-high (H-H) LISA relation indicates that a neighborhood with a significantly higher value is surrounded by neighborhoods with higher values, while a lower neighborhood value is surrounded by a lower neighborhood value for a LISA low-low (L-L) relation. A high-low (H-L) LISA relationship indicates that a neighborhood with a higher value is surrounded by neighborhoods with lower values, while a lower neighborhood value is surrounded by neighborhoods with higher neighborhood values for a low-high (L-H) relationship.

The PCA pattern is triangulated with the LISA pattern to augment the internal validity of the findings. The LISA interpretations were further synchronized with formal and informal settlement morphologies from a Quick bird image of 2009 (for MDI 2007) and a historical Google image from 2016 (for MDI 2016). In addition, our previous study and ground verifications of informal settlements enriched the interpretations of the overall findings. By interpreting low (LISA L-L) and high (LISA H-H) deprivation clusters, areas of polarization of poverty and spatial inequality were identified for each PCA component.

3.7.3. Method of Data analysis for specific objective 3

3.7.3.1. The environment level analysis methodology

Based on the LRA (Logistic Regression Analysis), the binary dependent variable "category 1" indicates a deprived area (informal settlement), and "category 0" indicates less deprived area (formal settlement). The study used independent variables such as river buffer and slope based on GIS analysis of the 30 m digital elevation model provided by the European Space Agency. The study also used variables from LULC 2013 and LULC 2021 and WorldPop gridded population data (WorldPop, 2010 and WorldPop, 2020) as independent variables. The integrated dependent and independent variables obtained through ArcGIS overlays are exported to SPSS 26 for LRA. See figure-6 for the overall methodological analysis using GIS and LRA. LRA is a statistical analysis method to predict binary outcomes, such as yes or no, based on the prior observation data set as stated in the following equation. If a predictor is binary, the odds ratio is equal to “e” or $\beta [e^\beta]$. The logit is the natural logarithm of the odds of p and Odds are the ratio of

the likelihood of “ p ” occurring [π] or not occurring [$1-\pi$] (Chao-Ying, Joanne, kuk, Gary, 2002; Hoffman, 2015). Equation-7 extends the logic of simple LRA to multiple predictors. Equation (8) is derived by taking the antilog of equation (1) on both sides. π is the probability of the event and p is the outcome of interest. β_0 is the p intercept and regression coefficients range from β_1 to β_n , while x_1 to x_n are predictors.

$$\text{Logit}(p) = \text{natural log}(\text{odds}) = \ln\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n \quad \text{Equation (7)}$$

$$p = \frac{1}{1 + e^{-\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n}} = \frac{1}{1 + e^{-\beta_0 + \sum \beta_i x_i}} \quad \text{Equation (8)}$$

In line with the above formula, the odds are the ratio of the probability (π) of belonging to an informal settlement (i.e., environmental features predict informal settlement) to the probability ($1-\pi$) of a formal settlement. The independent or predictor variables are environmental features: rivers, slopes, green and open areas, trees and vegetation, built-up areas, and crop areas. An LRA model provides better-fit data if statistical tests such as likelihood ratio, score, and Wald tests show an improvement over the baseline or intercept-only model. The inverse of the natural log of the regression coefficient represents the increase or decrease in the risk of the outcome that is associated with the independent variable (Leon, 1998). Wald chi-square tests the statistical significance of each individual regression coefficient [β s]. Nagelkerke is the variation of r^2 in multiple regression (Chao-Ying et al., 2002). The omnibus test of the model coefficient tests whether the new model explanatory variables showed improvement over the intercept-only model. It uses the chi-square test comparing the log-likelihood of the baseline model and the new model NCRM [National Centers for Research Methods], (2023). The degree to which predicted probabilities agree with actual outcomes is expressed as either a measure of association or a classification table.

3.7.3.2. The settlement level analysis methodology

In Addis Ababa, informal settlement areas lie in inner-city slums, peri-urban informal settlements, and parts of the intermediate areas. The intermediate and suburban informal settlements are partly regularized. The morphological features of informal settlements are

irregular road networks, small building sizes, and haphazard building orientation. Dense and small buildings crammed together in space, as well as a lack of proper road access in some areas, are common features of Addis Ababa's inner-city slum. The small, irregular building size, spontaneous arrangement, irregular orientation of buildings, greenery, and open space characterize peri-urban informal settlements. The regularized informal settlements have shown a pattern of mixed regular and irregular road arrangements intermingled with substandard and standard buildings. Regularized informal settlements are the result of the transfer of property and land rights from poor to affluent groups, which depicts a landmark of social gentrification. Formal settlements have regular shapes and orientations of buildings and roads, as well as planned common areas—greenery and open spaces.

Based on the delineation of deprived and less deprived areas based on settlement level ontology, the area and percentage for deprived and less deprived areas were quantified in Arcgis 10.8 for each sub-city, central slum sub-cities, outside central slum sub cities, and at the city-wide level. Hence, the areas for deprived and less deprived areas were also computed at the above-mentioned spatial levels for 2010 and 2022. Based on the deprived and less deprived area estimates, the study computed the area and the annual rate of change for 2010 and 2022, based on the following formula (Yang, Guo, and Wang, 2020).

$$K = \left(\frac{U_{tj} - U_{ti}}{U_{ti}} \right) \times \frac{1}{N} \times 100\% \quad \text{Equation (9)}$$

In the above formula, K is the dynamic annual change rate of formal and informal settlement areas during the study period. U_{ti} is the area of formal or informal for 2010 and U_{tj} is the area of formal, and informal for 2022. N is the number of years between 2010 and 2022. The population size was obtained by converting the WorldPop population raster layers (WorldPop 2010, WorldPop 2020) to a vector point layer in a 100-meter by 100-meter grid cell for 2010 and 2020 as well (WorldPop 2010, WorldPop 2020). Yet, at this juncture, it should be known that there are variations in the estimate of total population size and approaches used for the gridded population data estimate by Worldpop and that of the official census projection. Nevertheless, the world population is estimated based on the population census, population projections for 2002–2020, and built-up and residential location datasets (WorldPop, University of Southampton, 2023). This reveals the spatial pattern of population distribution on a 100 by 100-meter grid, from which

a proportion of the population and population density can be estimated. First, the ARCGIS 10.8 tool extracted point layers from WorldPop raster layers. The point layers were extracted for the city jurisdiction of Addis Ababa at 100-meter by 100-meter grid intervals with embedded attributes of population size. Then, the ArcGIS 10.8 search by location was performed to select population points from population point layers—points that completely exist in the deprived and less deprived areas polygon layer. Then, the selected areas were converted to layers and analyzed regarding the proportion of population living in deprived and less deprived areas, as well as computing population density per hectare for deprived and less deprived areas. For uncaptured population points from WorldPop, due to their location in non-residential land uses (dominated areas of commercial, service, industry, and others), the proportion of population for deprived and less deprived areas was forecasted based on the proportion of population quantified for deprived and less deprived residential areas.

3.7.3.3. The object level analysis methodology

The analysis used the ML approach of object-based RF to extract features from 2010 aerial photographs of impervious and permeable surfaces. Because of its ability to accept multiband imagery, work with segmented images, generalize, learn, and make decisions by majority vote (Breiman, 2001; Guo et al., 2020; ESRI 2023), RF is useful for object-based applications. Object-based RF extraction of color from multi-resolution images is performed using ArcGIS Pro 2.8. ArcGIS Pro performs object-based segmentation by grouping segments depicting similar shapes and spectral and spatial characteristics. The classification schema was created primarily for impervious and permeable surfaces. Then, the objects are trained by taking sufficient samples representing each impervious and permeable surface specified in the classification schema. ESRI class definition files are generated using the RF classification method. The classification and training of object detection considered the different colors of building roofs, vegetation, grass, roads, and open spaces. The image is trained with a supervised, labeled data set of classification schema by taking large samples reflecting the different object categories. Because we want to extract roof color and are not interested in anything about the equipment on the roof, the spectral resolution is set to medium (12 scales are given out of 20 scales) for smoother output in ArcGIS Pro 2.4. To better differentiate buildings from roads and realize better radiometric resolution, the spatial detail in the RF classification process is set to a high scale in ArcGIS Pro (19 scales are

given out of 20 scales). Based on ground verification during settlement delineation, the typical slum represents the dominating irregular dark brown roofs, interspersed with colors of silvery light and white roofs, while the formal buildings have roofs of different colors with regular geometric shapes. The study included the result of confusion matrix as part of the analysis to better reason out and interprets the result of error of omission and commission in line with empirical frameworks of morphological properties at object level and shape index analysis. The building shape is analyzed based on informal or formal characteristics, as well as the color of the building roof (Bhardwaj and Kumar, 2019). The shape index (SI) that corrects the polygon size by dividing the perimeter of the polygon by the square root of the product 4π and the area of the polygon. The SI (shape index) is indicated by the following formula:

$$SI = \frac{p}{(\sqrt{4\pi A})} \quad \text{Equation (10)}$$

Where p is the perimeter of the polygon (in meters). A is the polygon area (in meter square).

As the shape becomes more complex and deviates from a circle, the dimensionless corrected SI increases.

3.8. Method of Data Presentation

3.8.1.Data presentation procedures for specific objective 1

The overall methodological presentation process for proposing ABS that considers the deprivations of sustainable livelihood capital assets, institutions, capability, risk, safety, and vulnerabilities, as well as socially excluded or vulnerable groups, is indicated on Figure 11.

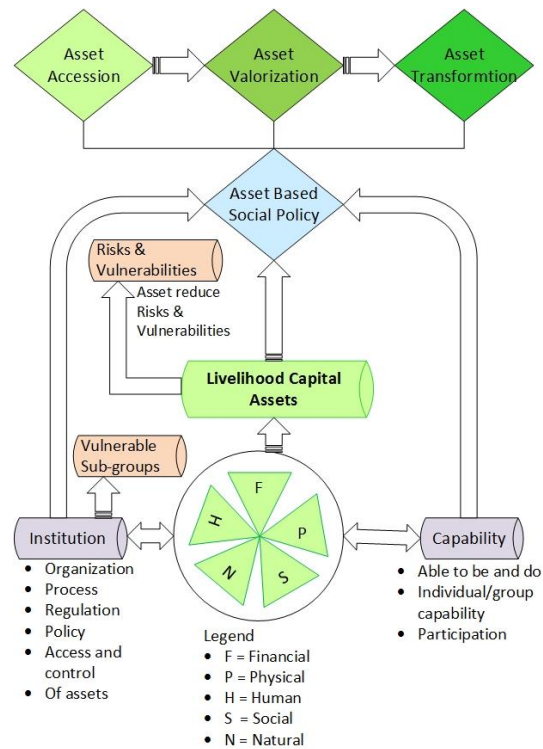


Figure 11 the conceptual model for analyzing the interrelationship in deprivations of sustainable livelihood capital assets and their implication for ABS.

3.8.2. Data presentation procedures for specific objective 2

The overall methodological process for presenting the spatial pattern of deprivations and inequality and the justification for area-based policy are illustrated in figures 12 and 13. Figure 12 indicates the GIS analysis part, while Figure 13 represents the SPSS analysis part.

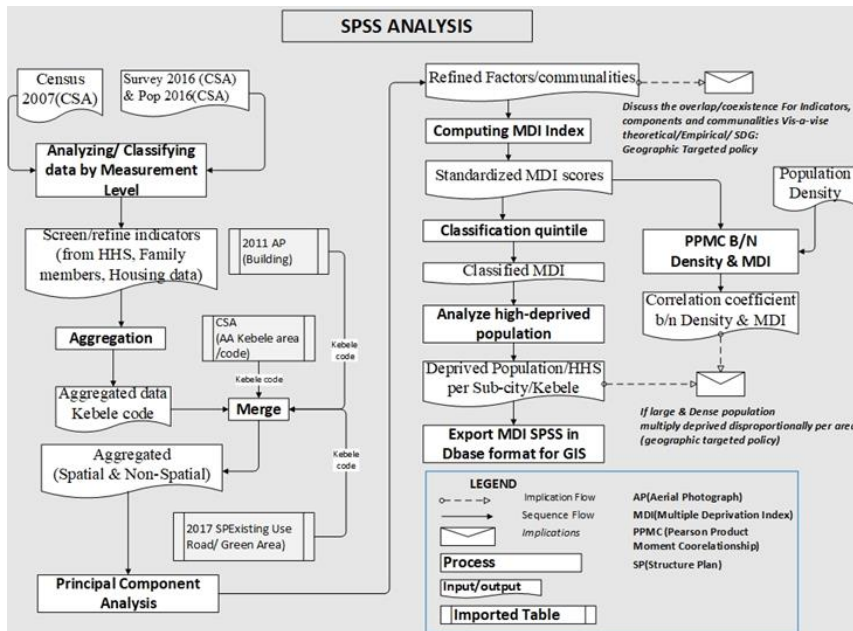


Figure 12 Methodological framework SPSS analysis

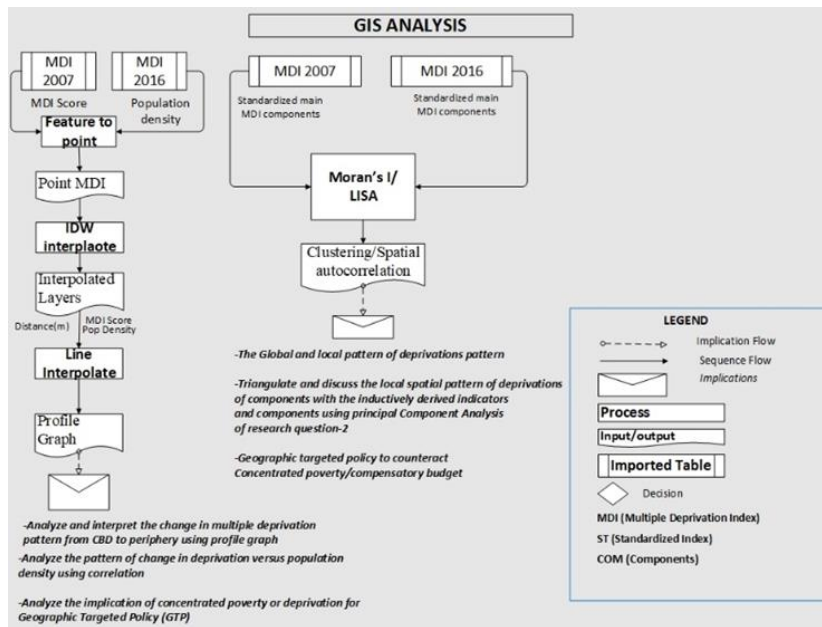


Figure 13 methodological framework GIS analysis.

3.8.3. Data presentation procedures for specific objective 3

The overall analysis of the urban morphology aspects of deprivations are disaggregated based on the conceptual model of slum ontology or deprived areas. The analysis of deprivation at the level of environment is illustrated in figure 14, the settlement level is illustrated on figure-15 and the object level is on figure-16.

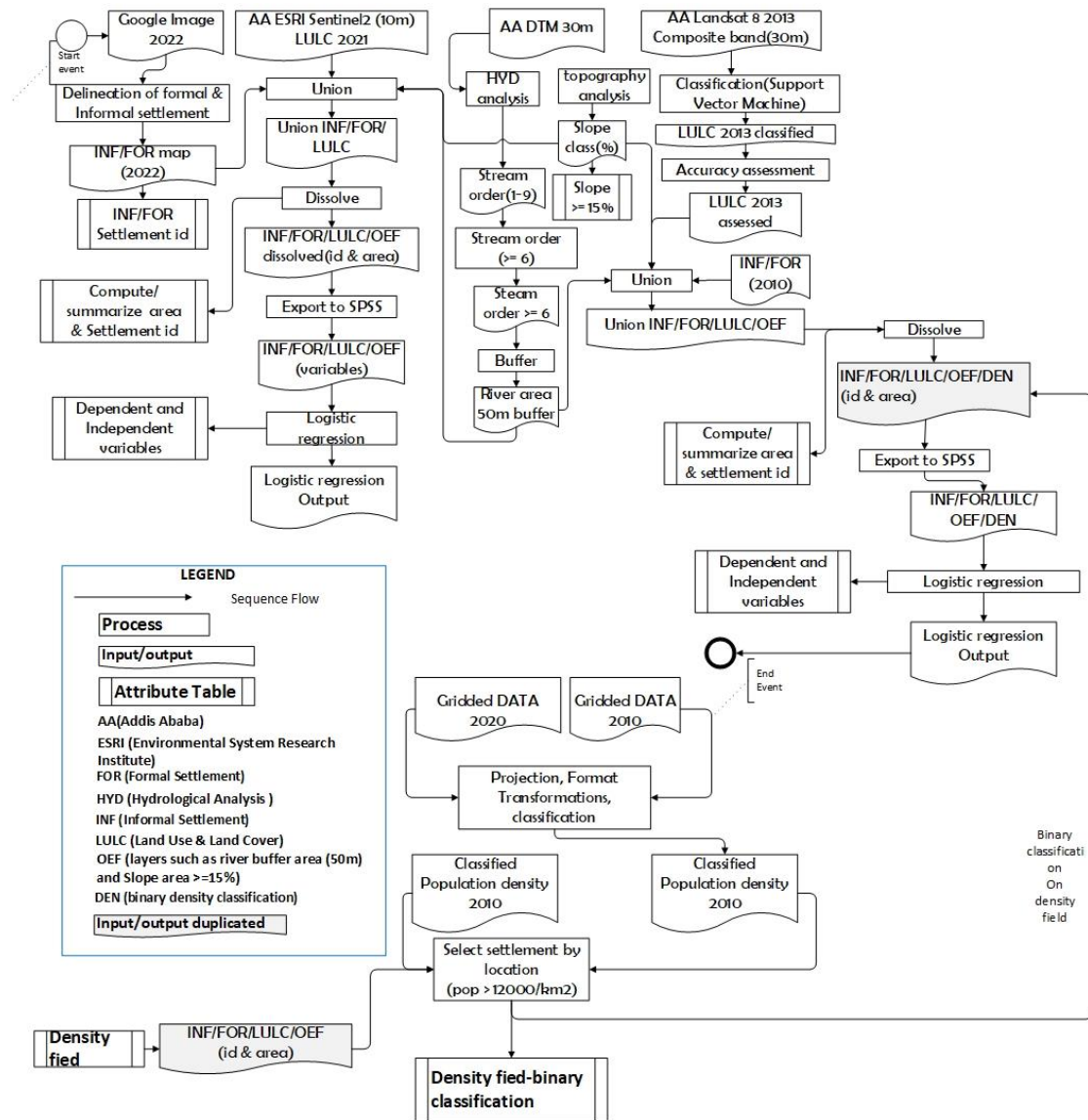


Figure 14 Conceptual model presentation for analysis of environment level

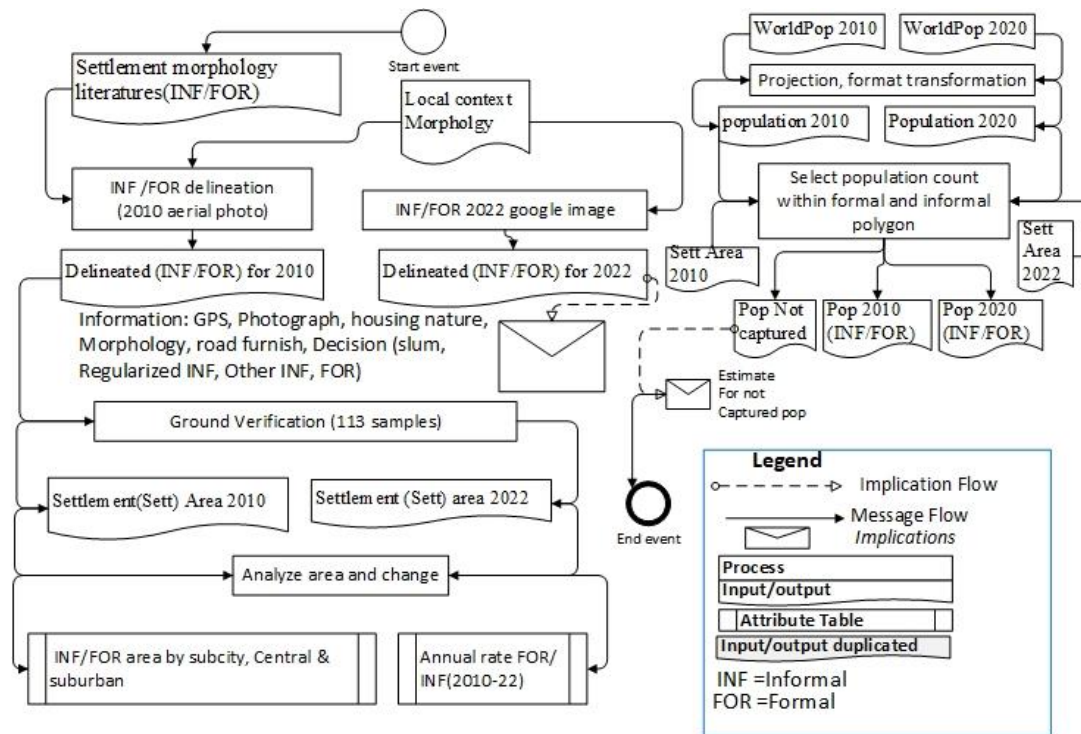


Figure 15 Conceptual model for analysis of settlement characteristics, extent and growth

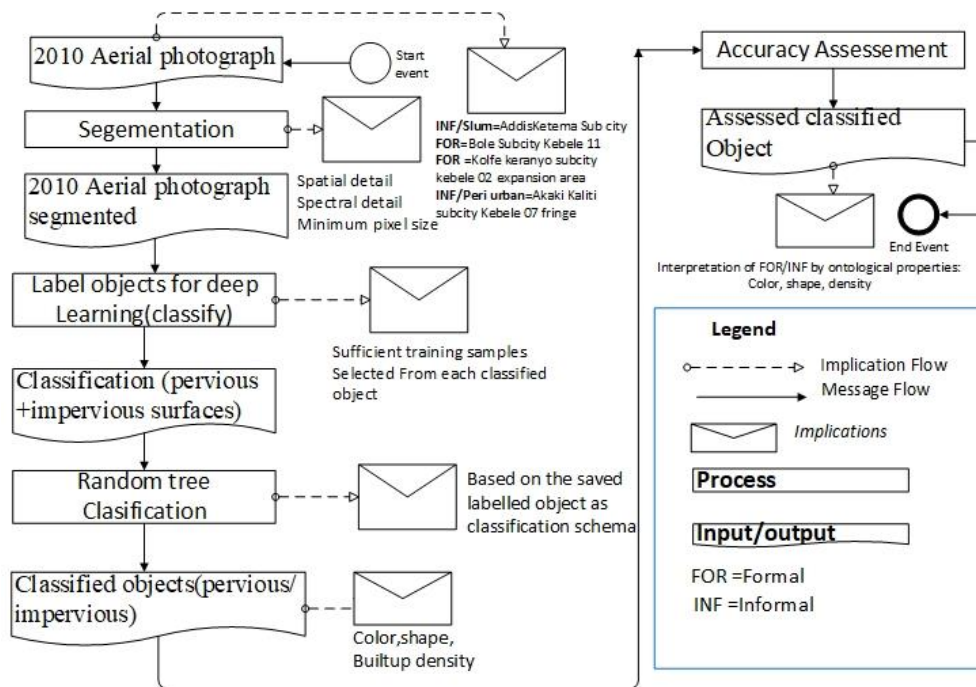


Figure 16 Conceptual model for analysis of building level

3.9. Validation and Reliability

3.9.1. Validation and reliability for specific objective 1

The two areas of Addis Ababa, representing "the inner-city slum" and "peri-urban," were chosen based on theoretical frameworks and purposive sampling by consulting officials. Then, representative samples were drawn from the finite population of the chosen Wereda informal settlement area using systematic random sampling. The steps ensured the external validity of the research by replicating the context in other informal settlement areas of Addis Ababa. Furthermore, the Wereda 07 administrative office's cadaster base map and a rental house's full-fledged information expanded, verified, and confirmed previously acquired information for the inner-city slum. The systematic random sampling procedures, including determining the sample from the finite population and HHs, as well as the sampling design and verification of quantitative information with document and qualitative individual case studies and key informant interviews, enhance the internal validity of the research.

To ensure reliability, internal validity, and logical generalizations, it is essential to gather and analyze reliable data that is intended for high integrity and accuracy. As a result, the data collection was carried out by six skilled and knowledgeable collectors—two for the peri urban area and two for the inner-city slum area. The data collectors' minimum educational background was that of a bachelor's degree holder, and five of them had a master's degree. The disciplines of the data collectors were related to urban planning, regional planning, and surveying. Before starting a comprehensive field survey, the researcher also instructed and oversaw the data gatherers in the pilot area and during the whole cycle of the field survey. Based on the pilot test feedback, the data collectors were reoriented on how to understand parts of the questionnaires, conduct face-to-face interviews during field surveys, and take measurements. Based on the pilot test, several unclear items were adjusted in response. Additionally, the reliability was increased by the triangulation of the information from closed-ended questionnaires with other data collection methods such as key informant interviews, individual case studies, and secondary documents (inner-city slums). The theoretical and conceptual lens of multiple aspects of livelihood, capital asset deprivations, and other pertinent theories allows for setting variables that measure hypotheses and research questions to realize content validity. The triangulation of the

closed-ended questionnaire, key informant interview, individual case study, other secondary sources, and empirical findings leverages the qualitative reliability of the study.

3.9.2. Validation and reliability for specific objective 2

The study triangulates the theoretical and conceptual frameworks with an emphasis on a spatial perspective regarding deprivation, poverty, livelihood, inequality, and vulnerability, and their interdependence and relationships. By screening variables, which measure the concept or construct, through the deductive theoretical lenses and the inductive empirical approach of MSAT, the research enhanced the content validity of the variables. The Construct validity is also enhanced by taking variables or constructs that measure the deductive concepts and theories. The internal validity is enhanced by triangulating and discussing the derived patterns and indicators of PCA with the spatial pattern derived from LISA. The findings were triangulated within the theory, empirical analysis, and SDG contexts to ensure external validity.

The procedure conducted for producing consistent, reliable, valid, and factorable data before further analysis is described based on tests of the KMO, BTS, and other measures of screening variables that measure the construct. The obtained KMO, which measures sampling adequacy, shall be greater than 0.5 when comparing observed and partial correlations, so the PCA analysis of indicators and components can proceed. The BTS measures the factorability of the inter-correlation matrix. If the BTS is less than 0.05, which implies that the null hypothesis that the correlation matrix is uncorrelated was rejected (Kaiser, 1974; Vijaya, 2010; Pishghadam, Noghani, and Zabihi, 2011). The correlation matrix in SPSS screened variables with significant correlation ($p < 0.05$). By creating a new set of uncorrelated, principal components through a data reduction technique, the PCA addresses the problem of multicollinearity. The existence of collinearity is detected by a large VIF (> 10), and if there is collinearity, the prediction is unreliable (Botsi, 2017). To maximize the factorability of the correlation matrix, the SPSS output of the rotated correlation matrix skipped the variable's SRC loading score between -3 and $+3$. The PCA interpretation skipped variables with a communality score of less than 0.3 due to the variable's weak relationship to a particular principal component (Rogerson, 2006). The average communality score should be between 0.5 and 0.6 for samples between 100 and 200, while it should be > 0.6 for samples under 100 (MacCallum, Widaman, Zhang, and Hong, 1999). In sum,

the triangulation of the inductively derived pattern with empirical and theoretical frameworks leverages the internal validity and the qualitative reliability of the study.

3.9.3. Validation and reliability for specific objective 3

Wald chi-square tests the statistical significance of each individual regression coefficient [β s] (Chao-Ying et al., 2002). If the Wald chi square test for logistic regression failed to reject the null hypothesis means that removing the variables from the model will not considerably damage the fit of the model (Analytica Datalab, 2021). Thus, Wald chi square test indicates whether the response variables of location and neighborhood characteristics involved in logistic regression is reliable enough to predict the outcome variable. Nagelkerke is the variation of r^2 in multiple regression (Chao-Ying et al., 2002). In this case indicates the reliability of the location and neighborhood characteristics independent variables in predicting deprived area. Yet, the Nagelkerke (r^2) depends on the number of independent variables explaining the dependent variables. In our case, we are only screening small number of environment variables related with location and neighborhood characteristics that the smaller Nagelkerke r^2 does not mean the independent variables are not reliable since Wald test will screen variables with statically significant regression coefficient. The omnibus test of model coefficient is used to check that the new model (with explanatory variables included) is an improvement over the baseline model. For the above test, the significant value of less than 0.05 indicates the current model outperforms the null model (IBM SPSS Modeler, 2021). The Omnibus test uses the chi-square test comparing the log-likelihood of the baseline model and the new model (NCRM, 2023). The degree to which predicted probabilities agree with actual outcomes is expressed as either a measure of association or a classification table (Chao-Ying et al., 2002)

The settlement delineation (formal and informal) is validated with 113 ground control points that verify whether the settlements delineated on the map reflect ground reality. First, verification points are selected from the image that represents formal and informal settlement neighborhoods with meticulous care, considering on the image the proportion of informal and formal settlements that exist in 2010 and 2022. Then, the researcher verified by going to the ground with GPS coordinates to that selected specific point along with a closed-ended questionnaire. The researcher photographed part of the area as evidence and linked the photograph with the GPS coordinates of that specific area. Then, the author filled in the characteristics of the area in the

format. The format of the closed-ended questionnaire is filled with the GPS coordinates of the location verified, the code of the verification point, and the relative location of the neighborhood as background information. Then, the closed-ended questionnaire is filled out with basic information regarding the dominant building type (standard, substandard, or a mix of standard and substandard), the road type (cobble, unpaved earth, gravel, red ash, block stone), and other roads. Then, based on the above evidence, a subjective judgment was made based on the dominant morphological characteristics whether the settlement is informal/slum, a regularized informal settlement, or a formal settlement.

Using a preliminary review of images, the 113 ground control points were evenly distributed throughout each sub-city, considering the area's formal or informal nature and the existence of settlements in 2010 and 2022 as indicated on figure 17.

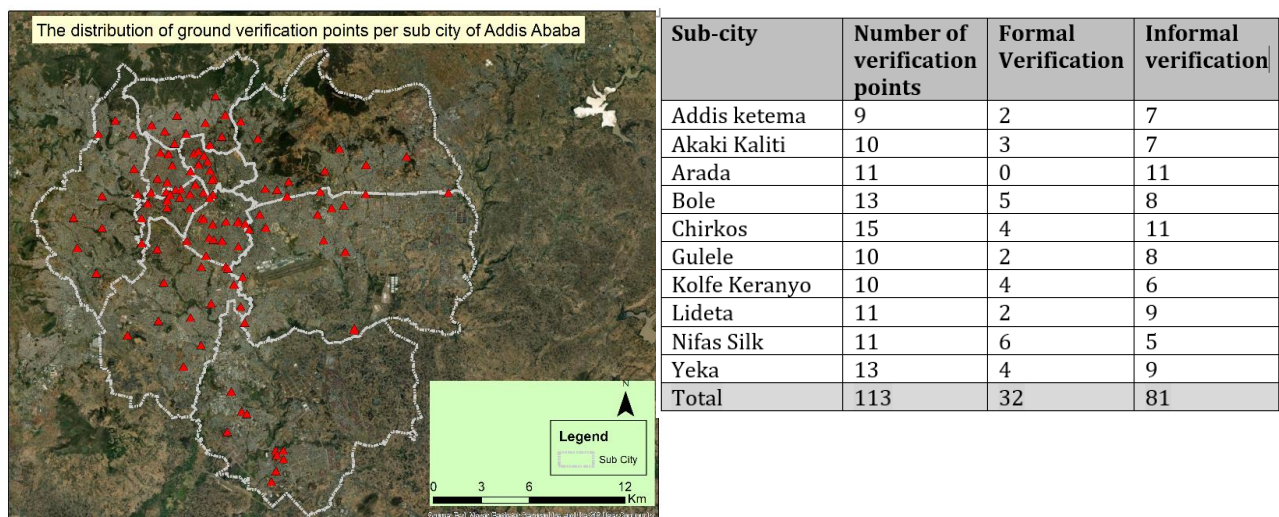


Figure 17 the distribution of verification points for validation of informal and formal settlements delineation for Addis Ababa city for classifying informal and formal settlements.

For object-based classification as well as the classified LULC for 2013, the study computed a confusion matrix including errors of omission and commission as part of validity and reliability. The study provided the producer's accuracy to ensure that real-world features on the ground (based on aerial photo 2010) are correctly shown on the classified settlement object, and vice versa for the user's accuracy. The producer's accuracy measures the error of omission, while the user's accuracy measures the error of commission. The error of omission represents pixels that

belong to the actual class but failed to be classified in the actual class. The error of commission represents pixels that belong to another class but are classified into a class (Remote Sensing and GIS Application, 2023). According to Landis and Koch (1977), a Kappa coefficient measures the degree of agreement between classification truth values: 0.81–1 [perfect agreement], 0.61–0.8 (substantial), 0.41–0.6 (moderate), 0.21–0.40 (fair), and < 0.21 (no agreement).

Chapter Four: Results and Discussion

4.1. Results

4.1.1. The interrelationships of sustainable livelihood capital assets deprivations and asset based social policy interventions: The case of Addis Ababa informal settlement areas, Ethiopia

4.1.1.1. Financial capital interrelationship with other livelihood capitals

The OWAUV revealed a significant difference in the percentage of expenditure for food, water, energy, and transport. Inner-city slums and peri urban HHs on average spent 61.36% and 55.8% on food, respectively. On the other hand, the inner-city slums and peri-urban areas spent < 5% and 9% on transport, energy/light, and water, respectively. The food expenditure percentage versus income per AE PPMC was -0.33 and -0.284 for the inner-city slums and peri-urban areas, respectively. The above result indicated that the poorer HHs, the greater the reliance on the cash economy for food security. The income per AE versus energy/light % expenditure PPMC was -0.33 and -0.32 for inner-city slums and peri-urban areas, respectively. Similarly, the lower the income per AE, the higher the percentage of investment in energy and light. A woman in a peri-urban area expressed the poverty and survival mechanism for the high-energy cost of charcoal as follows:

I am the only person supporting my children and husband by selling candles in front of the Kidane Mihret Church." My husband suffers from a mental illness. I have been compelled to sell my household's furniture to treat him. To cover the high cost of charcoal, I use charcoal residuals provided freely by charcoal sellers mixed with the soil that sustains long-term cooking (Case study 1, 2018, Kolfe Keranyo Wereda 03 peri-urban).

There was a significant association between sanitation vulnerability³ and HHs income per AE for inner-city slums ($\chi^2 = 36.635$, $df = 12$, $\alpha = 0.001$) and for peri-urban areas ($\chi^2 = 51.411$, $df = 12$,

³ Sanitation Vulnerability category: zero (No vulnerability: -pour Flush latrine shared by ≤ 5 HHs and Clean or Ventilated pit latrine shared by ≤ 5 HHs). One (Slightly Vulnerable:-Unventilated Pit latrine (not Shared) and Flush Latrine/latrine connected to Septic tank shared by > 5 and ≤ 10 HHs). Two (Vulnerable: Unventilated Pit latrine Shared by 2–10 HHs and Flush Latrine/ connected to septic tank shared by > 10 and $< =20$ HHs), Three (High Vulnerable: Unventilated Pit latrine Shared by > 10 and \leq

$\alpha = 0.001$). The fact was explained by the fact that the percentage of non-vulnerable to sanitation was 5.68% and 41.48% for HHs with incomes < 599 birr/M/AE and ≥ 3000 birr /M/AE, respectively. For peri-urban, the percentage of non-vulnerable to sanitation was 1.75% and 16.67% for HHs with incomes < 599 birr/M/AE and ≥ 3000 birr/M/AE, respectively. The OWAUV indicated significant differences in rental value per tenure status for the inner-city slum ($\alpha < 0.001$). The average rental value was Birr 16.3, 175.72, 591.8, 1420.41, and 2942.86 for Kebele House Rent, Municipal House Rent, rented from Unauthorized Dwellers, Sub-Renter from Kebele House Rent, and Rented from Owner Permit Right, respectively. The renters rented from owners of a permit right, and the sub-renter from a Kebele House (a government-rented house), both of whom were paying an exorbitantly high rent price. FHHs who rented a dwelling unit from the owner with permit rights expressed how the exorbitant rent was affecting her livelihood as follows:

My livelihood depends on selling "Areke", a traditional alcoholic drink, and renting a 12-m² house for 1,000 Birr per month. I paid the rent until now by saving through the local savings organization (Ekub). Yet, currently, the previous owner sold the house to another person, and the new proprietor asked me to pay 10,000 Birr per month; if I did not, he would rent it to a tenant who intended to use the structure as a bookstore. The Wereda office responded that they did not involve themselves in matters of the legally transacted house. Now I am really in deep grief since my livelihood depends on selling Areke; otherwise, I will be on the street (Case Study 2, 2018, Addis Ketema Wereda 07 inner-city slum).

There was a significant association between income per AE and the water source for peri-urban areas ($\chi^2 = 29.417$, $\alpha = 0.001$). The association for peri-urban was explained by 33.3% and 16.66% of HHs with income < 599 birr/M/AE and ≥ 3000 birr/M/AE, respectively, fetching water from springs with long waiting (4 Jerri cans per 15 days paying 10 birr per month in 2018). Similarly, HHs who use mainly vendor-provided water (10–13 birr/25 L Jerri can) were 26.14% and 61.4% for HHs with income per AE < 599 birr/M/AE and > 1500 birr to ≤ 3000 birr/M/AE, respectively. The SRC between income per AE and water consumption per Jerri can in liters for peri-urban areas was 0.4. The result indicated that the poorer the HHs in peri-urban areas, the less water consumption and vendor-provided water. Based on interviewing women and observation, the poor women in peri-urban areas brought potable water from the formal neighborhood at a reduced cost of 2 birr per 25 L of Jerri-can that mitigate the high cost of vendor-provided water.

20HHs and Flush Latrine/connected to septic tank shared by > 20 HHs), Four (Very High Vulnerable: Excreta Open Field, Bucket or Service latrine or Pit Latrine Shared by > 20 HHs).

There was a significant association between income per AE and building floor material for the inner-city slum ($\chi^2 = 71.783$, $\alpha < 0.001$), and there was also an association between income per AE and housing wall material for the peri-urban ($\chi^2 = 9.905$, $\alpha = 0.042$). The association with the inner-city slum was due to 54.35% and 1.09% of mud-floor houses having HHs incomes of < 599 birr per M/AE and ≥ 3000 birr per M/AE, respectively. The association with peri-urban was due to 100% of HHs having < 599 birr/ M / AE-constructed walls made of wood or mud. The PPMC between income/person/month and parcel area/person for peri-urban was 0.447. So, the higher income corresponded with large parcels per capita for land speculation in the peri-urban area. The PPMC between income per person per month and building area per capita was 0.365 for the inner-city slum. The above result indicated the vulnerability of the poorest of the poor to unhealthy and congested living conditions, considering the small size of their dwellings and the high family size of the poor. The SRC between income per AE and mobility in minutes from work to home was 0.31 and 0.168 for the peri-urban and inner-city slums, respectively. The result implicated the higher likelihood of going long distances for employment opportunities and better HHs income in peri-urban areas.

4.1.1.2. Interrelationships within human capitals and human capitals with other livelihood capitals

The PPMC between the number of unemployed youth (18–29 age group) and HHS members with educational status grades 9–10 was 0.334 and 0.302 for the inner-city slum and peri-urban, respectively. The result indicated HHs members who completed grade 10 but did not progress in further education constituted the highest number of unemployed youths. There was a significant association between gender and occupational status for inner-city slums ($\chi^2 = 52.316$, $\alpha = 0.001$) and peri-urban areas ($\chi^2 = 29.581$, $\alpha = 0.001$). The above association was due to 23.7% of FHHs in the inner-city slum (against 12.2% for MHHs) relying on assistance from children or relatives. Similarly, 3.3% of FHHs (and 8.53 percent of MHHs) relied on government employment as a source of income. Similarly, for peri-urban areas, the above association was due to 16.67% of FHHs (28.79% of MHHs) depending on formal employment⁴. There was a significant association between gender and HHs educational status for inner-city slums ($\chi^2 = 44.919$, $\alpha = 0.001$) and for peri-urban areas ($\chi^2 = 11.079$, $\alpha = 0.05$). The above result for the inner-city slums

⁴ Formal employment includes those who depend on Government Employment, Private organization formal, and Self-employed Formal business.

was attributed to 16.25% of FHHs (9.15% MHHs) being illiterate. In other words, there are 1.77 illiterate women for every male in the inner-city slum. For peri-urban areas, 38.5% of FHHs (15.24% of MHHs) belonged to either basic read and write or 1–4 education levels. In other words, in the peri urban area, there are 2.15 less educated women for every male. The significant association between marital status and an occupational category for the inner-city slum ($\chi^2 = 82.862$, $df = 45$, $\alpha = 0.001$) has gender implications. In the inner-city slum, 50.64% of widowed HHs depended on assistance from children or relatives (85.9% of the widowed were FHHs). The above result explained that the widowed FHHs were the most vulnerable to unemployment. From HHs > 60 years of age, 62.3% and 0.79% were surviving with the assistance of children and relatives for the inner-city slum and peri-urban, respectively.

There was a significant association between the education level of the HHs and the percentage of family members progressing \geq diploma education level for the inner-city slum ($\chi^2 = 29.008$, $\alpha = 0.016$) and peri-urban ($\chi^2 = 31.018$, $\alpha = 0.001$). The above result for the inner-city slums was explained by 59.3% and 30.8% of HHs of illiterate and \geq diploma level members not having any HHs members progressing to \geq diploma level, respectively. The association with peri-urban was explained by the fact that 100% and 60% of HHs with educational levels of illiterate and \geq diploma education level, respectively, did not have any family members progressing to \geq diploma education level. There was a significant association between unemployment and overcrowding status for the inner-city slum ($\chi^2 = 48.424$, $\alpha = 0.001$). The percent of employed HHs family members (18–64 age group) for the inner-city slum was 69.2% for the overcrowded category < 1 person per room and 34.9% for the overcrowded category of > 5 persons per room. There was also a significant association between over crowdedness and HHs grade level for the inner-city slum ($\chi^2 = 48.424$, $\alpha = 0.002$). The above association was due to HHs having high overcrowding (>3 people per room), which was 63% and 19.23% for illiterate and \geq diploma education levels, respectively. Accordingly, the less educated HHs in the inner-city slum were likely to be living in highly overcrowded housing. Yet, some dwellers in the inner-city slum had tenure insecurity, even though they lived for three decades as described below.

I have lived in the area for 29 years (since 1989), near the end of the ⁵Derg regime. The site was used for waste disposal during the Derg regime. We have participated in the Kebele election and funded contributions for development activities. I am now a grandfather, and my children were

⁵ The Derg regime ruled Ethiopia from 1974 to 1991.

born and brought up here. We have consistently written letters to the Addis Ketema sub-city Wereda 07 office to be legalized, at least with Kebele House rent. However, local authorities did not answer our consistent plea. We felt high insecurity by fearing that the government may evict us from the place without alternatives for our future livelihoods (Case Study 3, 2018, Addis Ketema Wereda 07 inner-city slum).

4.1.1.3. Interrelationships within physical capital

There was a significant association between overcrowding and sanitation vulnerability for the inner-city slum ($\chi^2 = 54.587$, $\alpha < 0.001$). The association for the inner-city slum was due to the non-vulnerable to sanitation constituting 61.5% and 5.8 % for HHs < 1 person/room and for HHs ≥ 4 to < 5 persons per room, respectively. The above findings indicate that overcrowding exposes poor dwellers to poor sanitation and transmissible diseases. There was a significant association between tenure status and HHs water source for inner-city slums ($\chi^2 = 65.269$, $\alpha < 0.001$). The association was due to vendor-provided water being the major source for 60%, 8.77%, and 0% of the unauthorized dwellers or renters, owner permit holders, and municipal house renters, respectively. The tenants, with unauthorized tenure right in the inner-city slum, were the most deprived of piped water connections. There was a significant association between sanitation vulnerability and tenure status in HHs for inner-slums ($\chi^2 = 33.348$, $\alpha = 0.031$) and peri-urban settlements ($\chi^2 = 22.869$, $\alpha = 0.029$). The above result was due to 100% of unauthorized dwellers and 48.51% of the renters being categorized as highly and very highly vulnerable to sanitation in the inner-city slum and peri-urban areas, respectively. The association of tenure right deprivation with poor sanitation and water services in a quarter of an inner-city slum indicated the impact of the absence of de jure tenure rights on the bargaining power of the poor for more services. An authorized dweller who lived in the inner-city slum elaborated that:

The toilet that serves 46 HHs' is overflowing and has not been repaired despite appeals to the Wereda 07 office. Therefore, the 46 HHs in the neighborhood are using a public toilet in the CCF office area (consisting of 34 toilets) by paying 12 birr per month, while during the night and during illness we are suffering due to a lack of toilets (Case Study 4, 2018, Addis Ketema Wereda 07 inner-city slum).

There was a significant association between tenure status and water vulnerability⁶ for inner city slums ($\chi^2 = 70.289$, $df = 15$, $\alpha < 0.001$). The association for the inner-city slum was due to 70%,

⁶ Water Vulnerability inner-slum: one (No Vulnerability) =Own Piped Water Connection not shared at all, two (less Vulnerable) =Piped Water Connection shared by 2 to ≤ 5 HHs, three (Vulnerable) =Piped Water Connection shared by > 5 to ≤ 10 HHs, four (High Vulnerability) = Piped Water Connection shared by $>$

11.3%, and 0% of the unauthorized dwellers, the owner permit rights, and the fact that municipal house renters were highly vulnerable to a potable water shortage. The result indicated that dwellers without de jure tenure rights were also highly prone to water shortages and paid a high cost for vendor-provided water in the inner-city slum. Regarding accessibility, 56.7% of the HHs were accessible within 0–15 m of a paved road for inner slums. Yet only 2.8% of the HHs were accessible within 0–15 m of paved roads for peri-urban areas. FHHs elaborated on the graveness of road inaccessibility services in peri-urban settings as follows:

I am a housewife. My husband is in construction. I lived in the hilly areas. I must go up the hill. I fetch water from Doro Erbata in the formal neighborhood because I must send my kids to school down the hill. In the settlement where we lived, when someone is ill or during pregnancy, someone must carry the person down the steep slope near Mariam Church to the spot of the taxi center. So, road and transport inaccessibility are the critical problems affecting our daily lives (Case Study 5, 2018, Kolfe Keranyo Wereda 03 peri urban)

Based on GIS service area analysis, 65.9% of HHs must commute > 1.5 km to access a primary school in the peri-urban area. 63.9% of the HHs shall commute > 3 km to access the health center for peri-urban areas. Yet, 100% of the inner slums were accessible to education and health services by < 1 and 1.2 km, respectively. The PPMC between primary schools and health services was 0.878 in peri-urban areas. The correlation indicated that social service deprivations were increasing with increasing distance from the formal neighborhood in peri-urban areas.

4.1.1.4. Interrelationships of social, financial, and physical capitals

There was a significant association between tenure status and CBO for peri-urban ($\chi^2 = 26.988$, $\alpha < 0.001$) and inner-slum ($\chi^2 = 25.117$, $\alpha < 0.001$). The association for peri-urban was due to 40.74% and > 78.3% of renters from unauthorized dwellers, and the remaining tenure groups were involved in at least one CBO, respectively. The significant association for the inner-city slum was due to 50 %, and > 81 % of the unauthorized dwellers and the remaining de jure recognized tenure groups were involved in at least one CBO, respectively. An elderly woman, with de jure Kebele house tenure rights, described that "Edir (CBO) members have participated and assisted me financially by reconstructing my demolished house beyond the assistance in case

10 HHs or HHs use vendor-provided potable water. Five (Very Highly Vulnerable) =use Water from River or not potable water sources.

of death and illness" (Case Study 6, 2018, Addis Ketema Wereda 07 inner-city slum). Yet, an unauthorized tenure right HHs mentioned that "Edir members assisted each other in cases where a person is ill and assisting families of the deceased did not extend beyond this (Case Study-7, 2018, Addis Ketema Wereda 07 inner-city slum).

The quantitative result coupled with the individual case study indicated that the extent of social capital is strong for de jure recognized tenure groups HHs in comparison to unauthorized dwellers in inner-city slums. In the peri-urban setting, renters from unauthorized dwellers were less involved in CBO. There was a significant association between participation in the election of Kebele and tenure status for peri-urban ($\chi^2 = 36.376, \alpha = 0.001$). The above association was due to the combined low plus very low election involvement of 51.9%, 28.6%, 21.8%, and 15.6% for HHs Rented from Unauthorized Dwellers, Peasant Authority Permission, Unauthorized Dwellers, and Owner Permit Right/Tax Receipt, respectively. The insignificant association for the inner-city slum explained that tenure status does not reflect involvement in the election in the inner-city slum. The unauthorized dweller in the inner-city slum described that "I have been contributing funds for development and participating in the Kebele election. Yet, we do not have legalized tenure rights. We feared that the government might evict us from the site that our children brought up" (Case study 8, 2018, Addis Ketema Wereda 07 inner-city slum). The above view indicated that the unauthorized dwellers considered enhancing social capital as a means of gaining tenure rights.

The unauthorized dweller in peri-urban mentioned that "she is participating in wereda elections while the wereda or local administration does not collect funds as part of community contribution for development activities even if we are interested in contribution" (Case study – 9, 2018, Kolfe Keranyo Wereda 03 peri-urban). The above result indicated how peri-urban unauthorized dwellers were excluded from contributing resources for development. There was a significant association between CBO and income per AE for the inner-city slum ($\chi^2 = 12.21, \alpha = 0.007$). The association was due to 7.39% and 23.53% of HHs, that were not involved in CBO, and had incomes < 599 birr/M/AE and ≥ 3000 birr/M/AE, respectively. The above result indicated that low-income HHs had higher social capital and networks as means of survival strategies in case of hardship.

4.1.1.5. Interrelationship of natural with human and financial capital

The overlaying of slope class with HHs GPS location screened the Vulnerable HHs. Accordingly, 50.8% of the HHs of peri-urban was living on slope > 20 percent, liable to flooding and landslides. For the inner-city slum, 21.8 % of HHs were vulnerable to constraints of topography. The topography constraints were due to 20.3% of HHs being on a 0–2% slope, liable for waterlogging and flooding, and 1.5% of HHs living on a riverside slope, susceptible to flooding and landslides. The natural capital (River) is highly contaminated with offending odor for inner-city slums, as most of the nearby river dwellers are disposing the toilets directly to the river. Based on GIS analysis, 38.9% of HHs of inner-slum were living within 50-meter distance from the river: - highly liable to offending smell and transmittable diseases. There was inverse PPMC ($r = -0.465$) between slope level and distance from the river for the innercity slum implicated the combined vulnerability of nearby river HHs to landslide, flooding, and water contamination. There was a significant association between income per AE and housing location to hazard for the inner-city slum ($\chi^2 = 31.066$, $\alpha = 0.039$). The association for the inner-city slum was due to 60.23 % of HHs living below absolute poverty line of Ethiopia located near hazard. The dominant hazard for inner-city slums were flood/drainage problems. For peri-urban, 97.6 % of HHs were prone to hazard regardless of income. The most prevailing natural hazards for peri-urban were flood/landslide-related.

4.1.1.6. The institutional aspects

The key institutions directly working on job creation and poverty alleviations in per-urban and inner-city slums were Job creation & Enterprise office (job creation & fund), Women and Children Affairs Office (jobs for women), Labor and Social Affairs office (registering unemployed person), Solid Waste Management Office(waste collection/sorting), UPSNP (relief assistance and protect livelihoods) and Community Mobilization Office (participation and job creation in infrastructure projects) and construction office (job in construction and infrastructure) (T. Getu, personal communication, October 22, 2021) and (A.Ketsela, personal communication, October 28, 2021).

The inner-city slum

The local administrative office worked with private organizations and associations (Addis Credit and Saving, Consumers, Handicraft, Dwellers Forums, and Addis Capital [lending machinery]). Non-Governmental Organizations (NGO) partnered with the local administrative office were Afro Health, Dawit Dreams, Amref Health Africa/CCCF, and New Integrated Development Enterprises. The local administrative office worked in partnership with the civic society associations (youth league, women's league, disabled, dwellers forum, condominium) for poverty alleviation and public mobilization. The local administrative office has a more decentralized administrative structure devolved from Wereda-Ketena-Block unit-HHs unit (A. Ketsela, personal communication, October 28, 2021). The decentralized nature of the structure makes it crucial to work closer to the people, ensure efficient service delivery, and realize safety and security. The NGOs complemented government work by bridging the gap in training UPSNP beneficiaries and addressing the needs of disabled and vulnerable women (S. Bogale, personal communication, November 3, 2021). The social and institutional capital accumulation is higher for the inner-city slum relative to the peri-urban, due to the array of actors (CBO, private, NGO, and civic society associations) involved. The allowed building permit regulation is mostly G + 7 and prohibits upgrading housing from substandard to standard materials (D. Abera, personal communication, January 15, 2018), which deters the capability of physical asset accumulation for the urban poor.

The Peri-urban:

The CBO, recognized in the local organizational structure, played a role in maintaining the houses of the vulnerable (the poorest of the poor, the disabled, and the elders) and providing educational facilities for chronically poor students. The local administrative office did not work with civic society associations (Women and Youth League) and NGOs (T. Getu, personal communication, October 22, 2021). The insignificance of social and institutional capital obscures the crucial roles of gender and youth in enhancing livelihood capital. The NGOs, as well as multilateral and bilateral agencies, are less involved in poverty alleviation. The World Bank assisted the programs of MSSE and UPSNP. The local administrative office has devolved the organizational structure from the Wereda-Ketena-block level for mobilizing development activities and ensuring safety and security (S. Eyassu, personal communication, October 20, 2021). Currently, farmers in peri-urban areas have de jure tenure rights that dwindle informal

land transaction. Yet, informal settlers who acquired land through agricultural land transactions are subject to a coercive measure of bulldozing, stripping homeownership (M. Birhan, personal communication, October 20, 2021), which creates a double standard in tenure ownership rights.

4.1.1.7. Capability aspects

The Inner-city slum:

The potential for individuals and collectives to accumulate livelihood capital is promising due to the diversity of partners working in government, non-government, private, and civic societies relative to the peri urban. Yet, the wereda administration did not authenticate and work with CBO despite 90.3% of HHs being CBO members. The government leveraged the individuals' capabilities in MSSE to be able to meet opportunities through a revolving fund. However, capital injections for microfinance have currently ceased due to previous beneficiaries' failure to execute payments. The above situation stunted the future development of microfinance and individual capability functioning at the expected level. The earlier MSSEs' were exemplary and created livelihood capital accumulation through job creation for others. Yet, some MSSEs were formulated by mobilizing their capital assets, while the poor did not have the initial cash to formulate an MSSE. The current functional credit institution (Addis Credit and Loan Association) interest rate is unaffordable (18 %) for the poor to engage in the business of their capability functioning. Addis Capital Goods and Finance provides asset-based lending after the MSSE's beneficiaries pay 15% of the machinery cost. Thus, because of unaffordable credit and a premium for machinery costs, most of the beneficiaries were middle- and high-income groups, while the poor engaged in rudimentary jobs that did not require high capital costs (A. Ketsela, personal communication, October 28, 2021). (A. Ketsela, personal communication, October 28, 2021).

Current research indicates that 58% of the wereda HHs were not self-sufficient in food, making it one of the poorest areas of Addis Ababa. The UPSNP program benefited all the target groups in the 1st and 2nd rounds (T. Bayu, personal communication, October 29, 2021). Since the area is closer to the CBD, the poor and vulnerable dwellers survived by diversifying their income sources by renting beds or houses and opening small businesses near their dwellings (E. Bayessa, personal communication, November 5, 2021). Under UPSNP, the beneficiaries participated in development activities through relief food assistance, compulsory saving of 1/5th of earnings as

a guarantee for graduation, and financial literacy, work culture, and technical training. The UPSNP also assisted in diversifying their income sources in the first and second rounds of the UPSNP program (T. Bayu, personal communication, October 29, 2021). After three years of graduation, 500 USD is granted (plus 36 months of 20% income savings plus additional income opportunity savings for MSSE), and graduates become microfinance clients involved in the business's functioning according to their capabilities. The major problems faced in UPSNP executions were screening beneficiaries, not engaging in diversified businesses, and the syndrome of expecting assistance after graduation (T. Bayeu, personal communication, October 29, 2021).

The participation office worked with offices such as UPSNP, the job opportunity enterprise office, construction, and finance. The residents contributed 65 percent of the project cost, while the government allocated a matching fund of 35 percent of the total infrastructure cost. The participatory-based cobblestone road and drainage projects generated job opportunities for the jobless and opportunities for the dwellers to participate in finance and labor. In general, projects executed by the participation office for 2020/21 through public mobilization included a public toilet, public kitchen, culvert, public shower, cobble maintenance, new and maintenance ditches and drainage work, a police center, bridge maintenance, green development, and street lighting. Based on the Wereda 07 administrative office, the project executions of the local administration office against what was planned for 2020/21 were financial (18.1%), knowledge and skill (10.7%), labor (9.5%), and material (12.9%).

The Peri-urban:

The institutional frameworks are not satisfactory due to the smaller number of institutions working in livelihood capital asset accumulation and the functioning of capability based on the preferences of the poor. The wereda administration office tied poverty alleviation efforts with income injection through the UPSNP program and the previous revolving fund of MSSE. Edir (the only accredited CBO in the local administrative structure) is engaged in maintaining houses for the chronically poor and providing educational facilities for students from impoverished families. Yet, the wereda administration did not make a commendable effort to partner with multilateral and bilateral agencies and civic society associations for capability functioning to ensure livelihood capital asset accumulation. No NGO is replicating the reputable experience on the management of MSSE and poverty alleviation (T. Getu, personal communication, October

22, 2021). The process of leveraging community capacity to build livelihood capital assets is rudimentary. The Wereda administrative office facilitated the formulation of MSSE, members' fund allocation, and job choice commensurate with capability. The wereda administrative office equipped the beneficiaries with financial management skills, developing trust among members, and strengthening the sustenance of MSSE (G. Bihonegn, personal communication, October 24, 2021). The Wereda job creation and entrepreneurship office quit providing credit for MSSE establishments after 2017 due to unpaid arrears of credit by beneficiaries. Currently, the participation of unemployed youth on MSSE has shown declining trends. Yet, some people formulated MSSE through the assembly of their financial resources (W. Getu, personal communication, November 1, 2021).

The disruption of financial capital injection also affected the accumulation of human and physical capital at MSSE for poverty alleviation efforts that provide lessons regarding the necessity of AB policy. Based on the HHs survey, 36% of the wereda dwellers were not self-sufficient in food. According to UPSNP, the vulnerable dwellers (formal and informal) obtained food relief assistance by investing their capability to leverage livelihood capital assets. The UPSNP program benefited the poor and poorest of the poor over a five-year stretch, focusing on the functioning of people's capabilities. The beneficiaries of UPSNP participated in livelihood capital asset accumulations through solid waste collection and sorting, beautification and greenery, soil and water conservation, gully rehabilitation, road infrastructure, and urban agriculture. The procedures for graduation of chronically poor HHs students involved in UPSNP are like the inner-city slum. A reasonable number of the UPSNP beneficiaries showed commendable outputs in the urban agriculture sector (T. Solomon, personal communication, October 21, 2021).

The contribution for infrastructure projects is 65% for residents and 35% for the government, respectively. Yet, the wereda administrative office excluded informal settlement dwellers from contributing 35% of resources for public work projects. The public participation projects executed in the year 2020/21 were cobblestone roads, open ditches, drainages, and streetlights (A. Yakem, personal communication, October 25, 2021).

4.1.1.8. Risks and vulnerabilities

The Peri-urban:

The main environmental risks are degradation of hilly and other areas and liability to gully erosion and flooding (T. Anteneh, personal communication, October 21, 2021). UPSNP included in the program the addressing of the above environmental issues. Based on a 2018 survey, 82.1% of the HHs claimed that the main hazards were steep slopes and flooding. The security and safety risks are personal fights, robbery, burglary, and land invasions (T. Kuma, personal communication, October 28, 2021). According to Kolfe Keranyo Werda 03 Health Office for 2020/21, the top four leading causes of morbidity were: respiratory tract infection, urinary tract infection, inability to swallow, and tonsillitis.

The Inner-city slum:

The main environmental risks were overcrowding and congestion, waste disposal problems, sanitation problems, and a shortage of green space (F. Zeleke and Amedmariam H., personal communication, November 1, 2021). Based on the 2018 socio-economic survey, 47% of HHs claimed no hazard in the neighborhood, 21.8% (flood and drainage problems), 6.7% (toilet excreta smell or overflow), and 6.4% (near a polluted river). The types of security and safety risks include robbery, personal fights, burglary, gambling, and illegal houses of shisha smoking and chat chewing (T. Eshetu, personal communication; G. Berhanu et al., November 5, 2021). According to Addis Ketema Addis Raey Health Station, the top four leading causes of morbidity for 2020/21 were urinary tract infection, medical certificate issue, diarrhea, and head injury (due to crime and fight).

4.1.2. The Spatial Pattern of Deprivations and inequality: The Case of Addis Ababa, Ethiopia

4.1.2.1. PCA Result for MDI 2007

SPSS 20's correlation matrix identified 23 indicators or variables with significant correlations ($p < 0.05$). The overall collinearity was 5.108 (no-collinearity), exceeding the determinant threshold ($p > 0.00001$). The KMO was 0.842, which implied the sample size was sufficient to proceed with factor and PCA analysis. The BTS was significant ($p < 0.001$), and the Chi-square (χ^2) was 3151.339 to reject the null hypothesis that the correlation matrix is uncorrelated. The commonality for all 23 variables in the 2007 census was greater than 0.3. The commonality (r^2), or percent of variance explained by the model, was > 0.6 for all 23 indicators of the MDI 2007. The first, second, third, and fourth components explained 40.25%, 26.97%, 9.218%, and 4.783% of the variation in the original data set, respectively. The commonality is > 0.6 for all indicators and > 0.89 for nine (9) indicators. The average commonality for all MDI 2007 indicators was 0.81. See Table 7 for a further result of the 4 components and 23 indicators.

Component 1 (LHSS):

It is named Low Human Capital and Substandard Services (LHSS), which is based on the strength of this component's indicators' loading scores and the direction of relationships. In generic form, the loading score (>0.76) is higher for three indicators describing low human capital asset proportions (higher illiteracy, deprivation of a high education level, and a higher proportion of young dependents). This component has a high loading score (>0.59) in generic form for substandard housing materials, poor housing facilities, poor services (sanitation, water, modern cooking), less electricity provision, and a low proportion of waste disposal services. In sum, this component's physical deprivation and low human capital are crucial aspects.

Component 2 (HEPSV):

It is named Health, Social, and Physical Vulnerability (HEPSV) based on the strength of the loading score (>0.48) for three indicators that contribute to public health deterioration (higher overcrowding, higher population density, and higher disability). The high loading score (>0.66) for the indicators (unemployment and FHH widows or divorced) demonstrates the area's social and economic vulnerability. The area's physical assets and private tenure ownership deprivations were implicated by the high loading score (>0.7) for indicators (old-aged houses and private tenure owner deprivations). HEPSV loading scores, on the other hand, describe a lower deprivation of electric light and waste disposal services (-0.4), which is typical in the inner-city area. The lower percentage of young dependents (-0.53) relative to other components means the area has an older population.

Component 3 (VUSG):

It is named Vulnerable Social Groups (VUSG), primarily considering the high loading score (>0.72) for indicators of vulnerable groups (a higher proportion of old dependents and a higher proportion of migrants). VUSG's loading score (-0.71) explains the low percentage of bathing facilities. Furthermore, this component ranks second, relative to other components, regarding the proportion of FHH widows and divorced, illiterate HHs, aged houses, and lack of access to electricity.

Component 4 (PHSC):

This component is known as "poor housing services and congestion" (PHSC) due to a high loading score (>0.4) of low physical capital assets (no specific kitchen room in the house and a high proportion of deprived electric lighting). It also indicated a high loading score (>0.3) for high population density next to the second component. The non-provision of electrical services is a peri-urban or fringe neighborhood settlement feature. This is because the government did not install electricity on undeveloped land in accordance with the statutory plan. The deprivation of the kitchen reflects the features of inner-city slums and peri-urban informal settlements.

Table 7 Rotated Component Matrix of PCA for 24 deprivation indicators and 4 components/factors based on the 2007 census for Addis Ababa City.

Indicators	Communality	Component 1	Component 2	Component 3	Component 4
		LHSS	HEPSV	VUSG	PHSC
Illiterate population	0.899	0.783		0.438	0.301
Degree-level education-deprived	0.763	0.826			
Wall-deprived	0.817	0.566	0.586	0.388	
Floor-deprived	0.930	0.928			
Ceiling-deprived	0.922	0.819	-0.484		
Aged houses	0.935	-0.321	0.703	0.566	
Deprived housing facilities	0.935	0.938			
Over crowdedness	0.855	0.305	0.85		
Population density	0.730		0.759		0.324
Own piped-water-deprived	0.667	0.809			
Sanitation-deprived	0.763	0.829			
Waste disposal-deprived	0.851	0.796	-0.427		
Modern cooking-deprived	0.869	0.886			
Electric-light-deprived	0.925	0.59	-0.520	0.359	0.411
Bathing facility proportion	0.598			-0.714	
Kitchen-deprived	0.788		0.376		0.786
Private tenure owner deprivations	0.919	-0.471	0.812		
Disabled population	0.349		0.484		
Migrant population	0.869	0.415		0.727	0.317
Widowed/divorced FHHs	0.889		0.670	0.620	
Unemployment	0.613		0.768		
Old dependency rate	0.890			0.897	
Young dependency rate	0.904	0.767	-0.530		

4.1.2.2. PCA Result for MDI 2016

For MDI 2016, the correlation matrix in SPSS 20 screened 11 variables with significant correlation ($p < 0.05$). The overall collinearity was 0.005, exceeding the determinant threshold ($p > 0.00001$). The KMO was 0.652, which assured that factorial analysis could proceed for MDI 2016. The BTS was significant ($p < 0.001$), and the Chi-square (χ^2) was 461.879, significant enough to reject the null hypothesis that the correlation matrix is uncorrelated. The variations explained by the first, second, and third factors/components are 27.44%, 20.620%, and 11.87%, respectively. The average communality for all MDI 2016 indicators was 0.633. See Table 8 for a further overview of the three components and eleven indicators.

Table 8 Rotated Component Matrix of PCA for 11 deprivation indicators and 3 components of MDI 2016.

Indicators	Communality	Component-1	Component-2	Component-3
		CLVS	LSES	EVIN
Illiterate HHs	0.687	0.299	0.703	0.323
Non-degree HHs	0.425	-0.312	0.572	-0.010
Self-employed HHs	0.600	-0.020	0.774	-0.024
Unemployed HHs	0.263	0.478	-0.168	-0.082
2016 income per AE	0.548	-0.096	-0.719	-0.147
Widowed/divorced FHHs	0.643	0.777	0.196	-0.027
Older HHs	0.607	0.779	0.009	0.018
Building density	0.781	0.660	0.232	-0.540
Population density	0.702	0.584	0.371	-0.473
Green per capita	0.807	0.012	0.097	0.893
Road per capita	0.906	-0.183	0.076	0.931

Component-1 (CLVS):

It is named “Congested Living and Vulnerable Social Group (CLVS)” considering the high positive loading score for indicators of this component. The high loading score (> 0.47) for widowed or divorced FHHs and unemployed HHs explains the high proportion of vulnerable groups. The high loading score (>0.58) for buildings and population density also signified substandard housing and a lack of living space for vulnerable groups. The overcrowded living conditions and concentration of vulnerable groups depicted Addis Ababa’s inner-city areas.

Component 2 (LSES):

This component is called “Low Socio-Economic Status (LSES)”. The higher positive loading scores (>0.57) for the percentage of non-degree HHs, illiterate HHs, and self-employed HHs are interwoven to form low human capital assets. On the contrary, there is an inverse relationship between low income (-0.719) and a high proportion of illiterate HHs (0.687), a low proportion of degree-level HHs (0.425), and a high proportion of low-paid self-employed jobs (0.6). As a result, low income and low human capital assets result in low socioeconomic status. The preceding statement indicates that low education leads to low-income and low-paid jobs that, in turn, enforce poverty traps for individual HHs and neighborhood HHs, which seeks further research on the negative neighborhood effects of poverty concentration.

Component 3 (EVIN):

The component is named Environment and Infrastructure (EVIN) based on the high loading score for green space and roads per capita. The EVIN component revealed an inverse relationship between a high proportion of roads per capita (0.931) and green per capita (0.893) on the one hand and a low proportion of the population density (−0.473) and building density (−0.54) on the other hand. In general, the amount of green space and infrastructure per capita is low in overcrowded slum areas, while it is high in newly developed, formal suburban areas.

4.1.2.3. Computing Non-Standardized MDI (NSMDI) and Standardized MDI (SMDI)

The NSMDI and MDI were computed for MDI 2007 and MDI 2016. The four components of MDI 2007 and the three components of MDI 2016 explained the overall variation of 81.2 percent and 59.93 percent of the original datasets, respectively. The NSMDI and MDI were computed for 2007 and 2016 for components with Eigen values > 1.

$$NSMDI_{2007} = \left(\frac{40.25}{81.22}\right) \times (f1) + \left(\frac{26.97}{81.22}\right) \times (f2) + \left(\frac{9.22}{81.22}\right) \times (f3) + \left(\frac{4.78}{81.22}\right) \times (f4)$$

$$NSMDI_{2016} = \left(\frac{27.44}{59.93}\right) \times (f1) + \left(\frac{20.62}{59.93}\right) \times (f2) + \left(\frac{11.87}{59.93}\right) \times (f3)$$

The MDI was computed for 2007 (MDI_{2007}) and 2016 (MDI_{2016}) based on the formula below.

$$MDI_{2007} = \left| \frac{(NSC - NLV)}{(NHV - NLV)} \right| \times 100 = \left| \frac{(NSC - (-1.8982))}{(1.3954 - (-1.8982))} \right| \times 100$$

$$MDI_{2016} = \left| \frac{(NSC - NLV)}{(NHV - NLV)} \right| \times 100 = \left| \frac{(NSC - (-1.3101))}{(1.5547 - (-1.3101))} \right| \times 100$$

4.1.2.4. The Overall Spatial Pattern of Deprivations Concentration

For the MDI 2007 classification, the most deprived quarters were pervasive in most parts of the city, while the intensity of deprivation was less for most of the intermediate areas. Yet, for the MDI 2016 classification, the most deprived areas showed vivid clustering in the inner-city slums and peri-urban informal settlements, while the intermediate and formal suburban areas were less deprived quarters. See Figure 18 for MDI 2007 and MDI 2016 deprivation classifications.

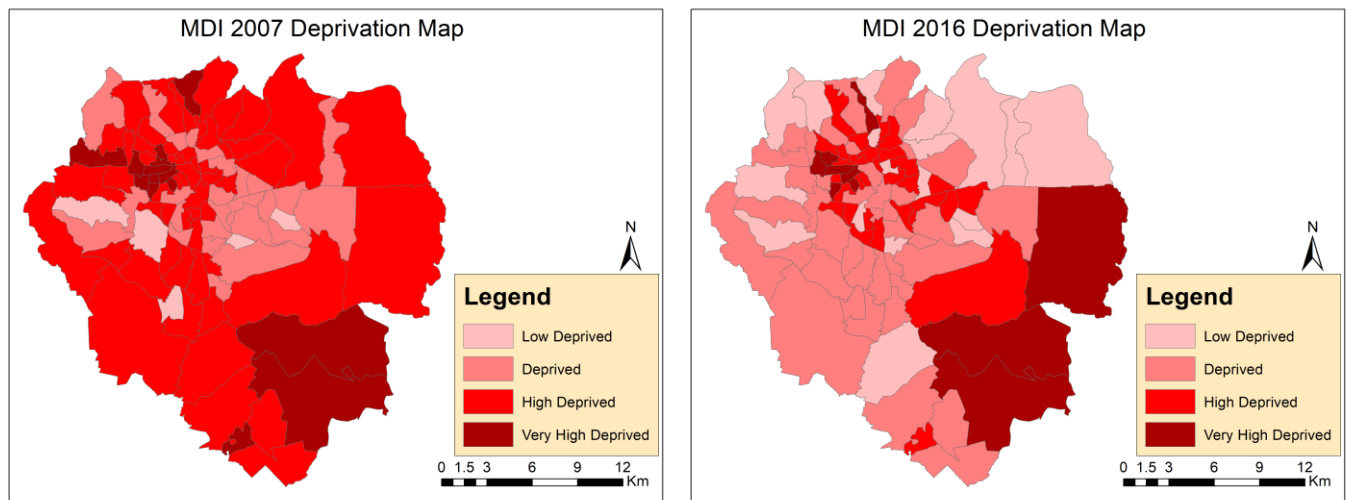


Figure 18 Deprivation classification for MDI 2007 and MDI 2016.

Table 9 Moran’s index for components of MDI 2007 and MDI 2016

Component (2007)	Component 1 (LHSS)	Component 2 (HEPSV)	Component 3 (VUSG)	Component-4 (PHSC)
Moran’s I (2007)	0.463	0.604	0.478	0.469
Component (2016)	Component-1 (CLVS)	Component-2 (LSES)	Component-3 (EVIN)	
Moran’s I (2016)	0.363	0.283	0.445	

For components 2007 and 2016, the result of Moran’s I indicated significant positive spatial autocorrelation, while the strength of the “Moran’s I” coefficient was high for MDI 2007, relative to MDI 2016, due to the consideration of a multitude of census indicators. The global “Moran’s I” for MDI 2007 and MDI 2016 indicated that neighborhood units with high deprivation scores were close to each other, revealing the spillover effect of poverty

concentration on adjacent neighborhoods. Component 2 (HEPSV) of the MDI 2007 demonstrated strong positive spatial autocorrelation, relative to other MDI 2007 components, justifying how the deterioration of public health and vulnerability formulated a concentrated poverty pattern and spatial inequality. For MDI 2016, Moran's I result was positive and strong for component 3 (EVIN), compared to other MDI 2016 components, verifying how a lack of road infrastructure and green space per capita leads to a pattern of concentrated poverty. See Table 9 for the result of the global "Moran's I" index.

4.1.2.5. The Local Spatial Pattern of Deprivations and Inequality for MDI 2007

The LISA H-H (red color) showed high deprivation in inner-city slums as well as informal settlements (peri-urban and suburban areas) for MDI 2007, while the blue color indicated low deprivation clusters (LISA L-L). The light blue on the LISA indicated low-high (L-H), while the light red indicated high-low (H-L).

MDI 2007 Component-1 (LHSS) spatial pattern

The LISA H-H relation indicated a high level of deprivation in the suburbs and peri-urban areas of the Bole and Akaki Kaliti sub-cities. In conjunction with this component PCA pattern, the high deprivation spatial pattern suggested a lack of durable housing materials, environmental services, and human capital assets in the outskirts informal settlements. Low deprivation was identified by the LISA L-L for areas that were dominated by formal settlements (the sub-city areas in the eastern parts of Chirkos, parts of Yeka, and the northern part of Bole). Hence, the LISA L-L showed that the Arada sub-city, which served as Addis Ababa's former cultural and educational hub, had a low concentration of deprivations. Look at Figure 19 for a further overview.

MDI 2007 HEPSV (component 2) spatial pattern

The LISA H-H relationship revealed a high concentration of deprivation in inner-city slum areas. In line with the PCA result for this component, inner-city slums were severely deprived in terms of public health, housing deterioration, and socio-economic vulnerability. Following LISA H-H, the most deprived areas were the entire Addis Ketema sub-city (old CBD), the Lideta sub-city (except for the southwestern part), the western parts of Arada, and the southern parts of the Gulele sub-city. This component showed low deprivation concentration (LISA L-L relation) in

the formal settlement-dominated sub-city areas of Yeka, Bole, Chirkos, and Akakai Kaliti. See Figure 19 for a further overview of the local spatial pattern.

MDI 2007 VUSG (component 3) spatial pattern

The LISA H-H depicted high deprivation concentrations in peri-urban areas of the Akaki Kaliti sub-city, the inner-city slum areas of the Arada sub-city (except the western strip), and the central part of the Gulele sub-city. Considering the PCA analysis of component 3, the high clustering of deprivation was attributed to the high proportion of migrants who severely lacked electric and bath services, reflecting the character of peri-urban settlements. Furthermore, the high proportion of old dependents as well as the repository of recent migrants reflected the character of the inner-city slum areas. The western neighborhoods of Kolfe-Keranyo and Nifas Silk Sub-cities, as well as strip areas of Bole sub-city, were the low-deprivation concentration areas for VUSG, mainly consisting of formal settlement areas. See Figure 20 for a further overview.

MDI 2007 PHSC (component 4) spatial pattern

The LISA H-H showed that deprivation of kitchens and electricity was the main pattern for the undeveloped areas in the peri-urban informal settlement areas of Bole and Akakai Kaliti sub-cities, as well as the inner-city slum areas of the Chirkos sub-city (the central part), Arada sub-city (the western part), and Lideta sub-city (the northern part). On the other hand, the northern suburban areas of Addis Ababa, especially the expansive mixed settlement areas of Gulele and Kolfe-Keranyo sub-cities, were the sites of LISA L-L clustering. See Figure 20 for a further overview of the local spatial pattern.

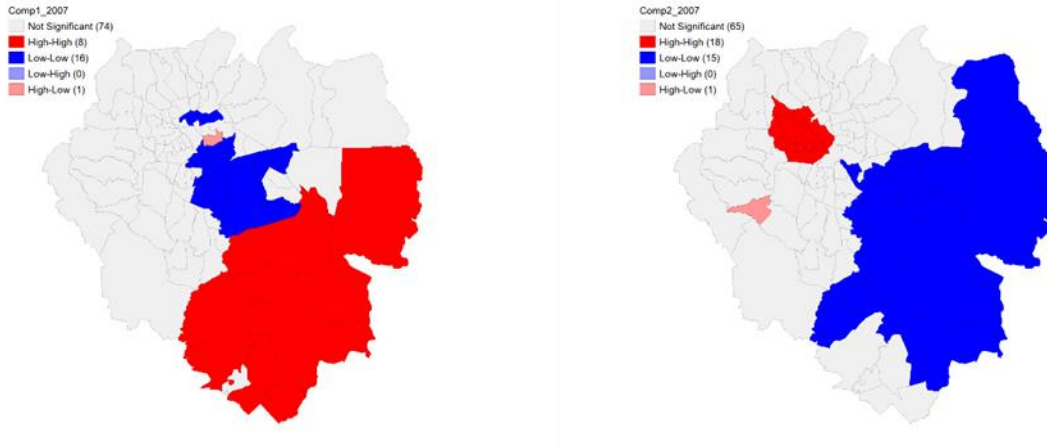


Figure 19 LISA cluster map for MDI 2007 component one [LHSS] on the left and component two [HEPSV] on the right.

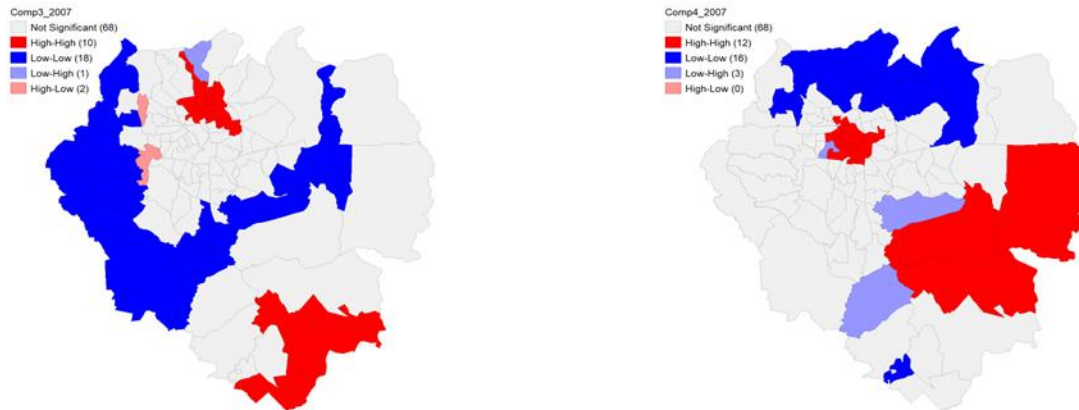


Figure 20 LISA cluster map for MDI 2007 component 3 [VUSG] on the left and component 4 [PHSC] on the right.

4.1.2.6. The Local Spatial Pattern of Deprivations and Inequality for MDI 2016

MDI 2016 CLVS (component 1) spatial pattern

The LISA H-H relation for this component depicted a high deprivation concentration in the purely inner-city slum areas of Lideta and Addis Ketema sub-cities. The low-density settlement parts, in the peripheral mixed neighborhood areas of the Kolfe-Keranyo sub-city (west) and the formal settlement areas of the Bole and Yeka sub-cities, showed areas of LISA L-L relation. In conjunction with the PCA result of this component, vulnerable social groups and congested living conditions were characteristics of the inner-city slum, while they were less prevalent in formal neighborhoods. See Figure 21 for further review of the local spatial pattern.

MDI 2016 LSES (component 2)

The LISA-H-H showed high deprivation concentrations in the inner-city slum areas of the Addis Ketema sub-city, the northern part of the Lideta sub-city, and the western part of the Arada sub-city. The LISA L-L showed clustering in the formal settlement neighborhoods in the north-central part of the Bole sub-city and a single formal neighborhood for each of the Chirkos and Nifas Silk sub-cities. Concerning the PCA findings of this component, the concentration of deprived human and financial capital assets was one of the features of the inner-city slums, while the intermediate formal areas were concentration areas for dwellers with high socioeconomic status, explaining why poverty was less polarized in formal neighborhoods. See Figure 21 for further review of the local spatial pattern.

MDI 2016 EVIN (component 3)

Based on the LISA H-H relationship, green and road space per capita showed high clustering in the intermediate and suburban areas of the Akaki Kaliti and Bole sub-cities. The aforementioned areas were newly developed formal areas with major road extensions for development; however, they consisted of sparse settlers in 2016. On the contrary, the inner-city slum sub-cities such as the Addis Ketema sub-city, Arada sub-city (the major parts), and Lideta sub-city (the northern part) showed LISA L-L clustering, explaining the lower proportion of green space and road infrastructure per capita for the inner-city slum areas. See Figure 22 for a further overview of the local spatial pattern.

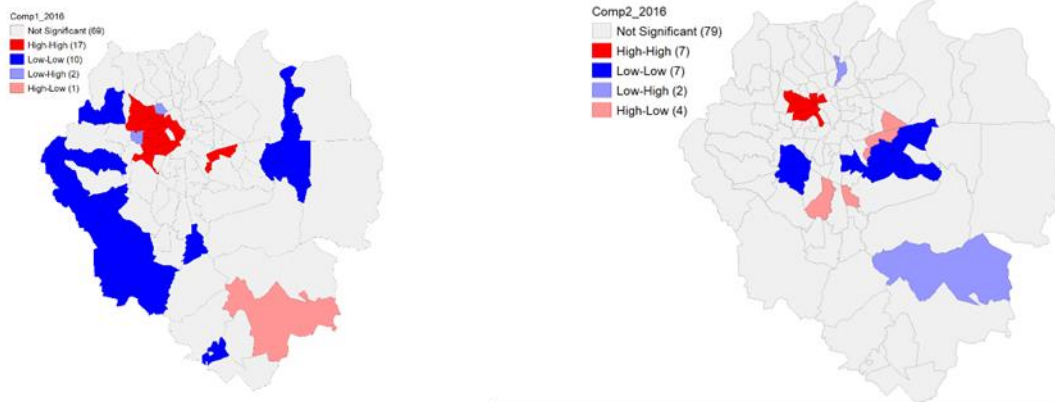


Figure 21 LISA cluster map for MDI 2016 component 1 [CLVS] on the left and component 2 [LSES] on the right.

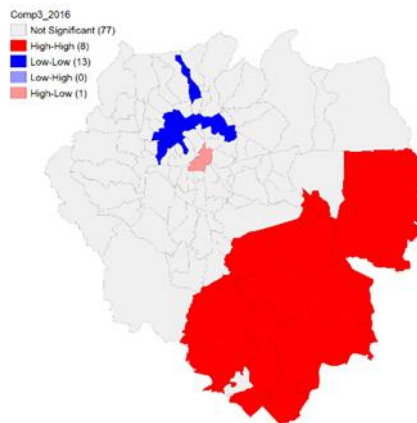


Figure 22 LISA cluster map for MDI 2016 component 3 [EVIN]

4.1.2.7. MDI Classification versus Deprived Population Proportion MDI 2007

The Addis Ketema sub-city had 81.1% of the VHD population, followed by the Lideta sub-city (27.8%). For the three sub-cities (Akaki Kaliti, Kolfe Keranyo, and Gulele), 10–15 percent of the population belongs to the VHD category. In the Akaki Kaliti sub-city, 85.3% of the population belongs to the HD category. HD populations ranged from 19 to 78% in Yeka, Gulele, Nifas Silk, Arada, Chirkos, Kolfe Keranyo, Lideta, and Addis Ketema sub-cities. Every Addis Ababa sub-

city had at least one kebele that belonged to the HD or VHD group. See Figure 23 for further overview of high and very high deprived proportions by sub city.

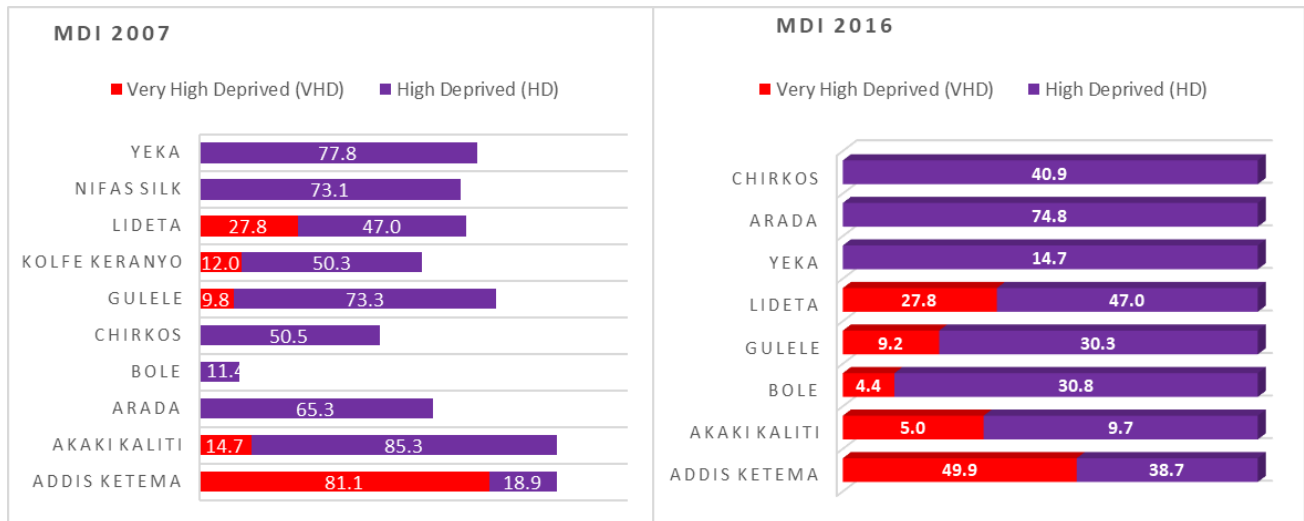


Figure 23 Very high-deprived (VHD) and high-deprived (HD) population percent for Addis Ababa sub-cities based on MDI 2007 and MDI 2016.

4.1.2.8. MDI Classification versus Deprived Population Proportion (MDI 2016)

Sub-cities of Addis Ketema and Lideta accounted for 49.9% and 27.8% of the VHD population, respectively. For Gulele, Akaki Kaliti, and Bole sub-cities, less than 10 percent of the population belongs to the VHD category. The Arada sub-city constituted 74.84% of the HD population. The other sub-cities of Addis Ababa (excluding Nifas Silk and Kolfe Keranyo) comprised 10–47% of the HD population. Sub-cities, such as Kolfe Keranyo and Nifas Silk, do not have a population that belongs to the VHD and HD categories.

4.1.2.9. MDI 2007 and MDI 2016 Comparative Assessment

The most deprived (VHD and HD) population constituted 68.6% and 33.0% of the MDI in 2007 and 2016, respectively. Deprivations have shown declining trends from MDI 2007 to MDI 2016, despite different indicators used for MDI construction. Nonetheless, more research into concentrated poverty, relating deprivation to population density, migration trends, and other factors, is crucial due to the increasing trends in the urbanization of poverty. Compared to MDI

2007, the MDI 2016 population proportion that belongs to HD declined for the sub-cities of Gulele, Akaki Kaliti, Chirkos, and Yeka (sharp decline). The Lideta sub-city population that belongs to HD remained similar in the intervening MDI periods. The Arada sub-city population proportion that belongs to HD increased for MDI 2016 relative to MDI 2007. For MDI 2007, the Kolfe Keranyo sub-city represented 7.1% and 50.3% of the VHD and HD populations, respectively. Nonetheless, for MDI 2016, 0% of the Kolfe Keranyo population has VHD or HD.

4.1.2.10. The Spatial Trend of Population Density versus MDI

The MDI 2007 and MDI 2016 graphs showed that deprivation peaks in the CBD area and then declines gradually with a noticeable drop in the intermediate city, then rises again until it reaches the equivalent of the CBD peak in the peri-urban area of Addis Ababa and then declines again towards the rural areas. For MDI 2007, the deprivation score shows a progressive decline until a high peak at 2 km from the CBD, and then again increases to reach a small peak at about 4 km. Then, deprivation showed a recognizable decline at about 5–9 km from the CBD, rose again, roughly equivalent to the CBD in peri-urban areas, and then declined towards the rural areas outside Addis Ababa's peri-urban area.

For MDI 2016, the deprivation score showed a sharp decline at 6 km from the CBD, an increase again from 6–7 km from the CBD, and a steady decline from 7–10 km from the CBD. Then, MDI 2016 illustrated a progressive increase to reach a peak equivalent to the CBD around the peri-urban area of the city. Again, MDI 2016 showed a progressive decline in the pure rural area outside Addis Ababa's peri-urban area.

The graph illustrated that the deprivation extent in the inner-city slum is consolidating and expanding since a sharp decline occurred at 2 km from the CBD for the MDI 2007, while the sharp decline was at about 5–6 km from the CBD for the MDI 2016. The population density declined sharply from the CBD, with two recognizable peaks at about 0.5–1 km and 2–4 km and a progressive decline (6–20 km) towards the outskirts of the city for the two MDI periods. The general trends for the two MDI periods revealed that deprivation score and population density had direct correspondence in and around the CBD. However, as one moves from the center of the city to the peri-urban areas, deprivation rises with the progressive drop in population density. The urban form and location, whether it is a formal or informal settlement, influence the spatial

concentration of deprivations. The PPMC between MDI 2007 and population density was 0.379. The PPMC between MDI 2016 and population density was 0.497. Based on the findings, deprivation has recently increased in direct proportion to population density, revealing the increasing trends of concentrated poverty in the slums of Addis Ababa (see Figure 24 for the spatial pattern cross-section of population density and deprivation as one goes from the old CBD to periphery).

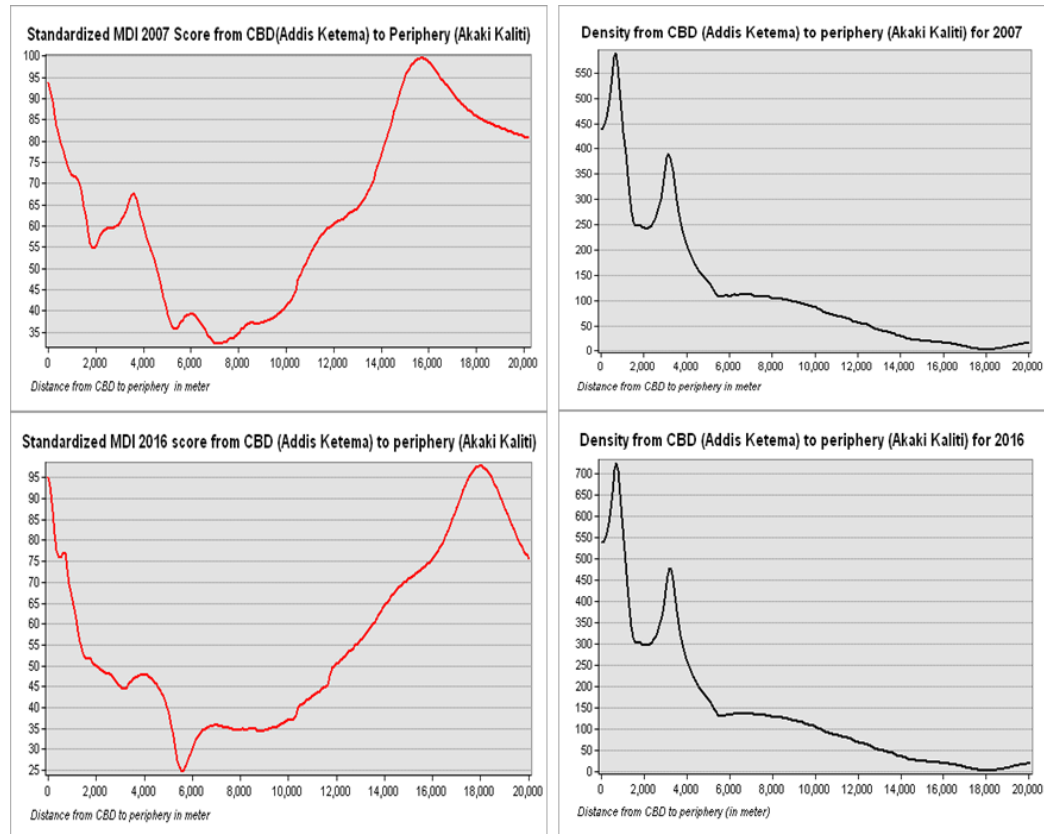


Figure 24 the cross-section of deprivation standardized score and population density of Addis Ababa city from the old CBD (Addis Ketema) towards the periphery (Akaki Kaliti sub-city).

4.1.3. Deprivations Patterns from urban morphology perspectives: the case of Addis Ababa, Ethiopia

4.1.3.1. Analysis of deprived areas versus environmental variables

LRA, in this study, makes predictions about the relationship between binary dependent and independent variables using the ODDS ratio. The independent variables are environmental factors, and the proxy indicator for deprivation is a binary dependent variable that indicates whether the settlement is an informal area (1) or not. Figures 25 to 27 show the spatial maps used to extract the independent variables. Table 12 shows the confusion matrix performed for sampled 500 points stratified based on LULC proportions before integrating as independent variables in LRA.

4.1.3.2. LRA analysis on settlement units (informal or formal) for 2011 versus environmental features (2013) and risk location (DTM)

The LRA is performed to analyze whether the existence of informal settlement is explained by environmental features extracted from LULC (see table 10) and environmental risk and deteriorated health. According to the analysis, the Omnibus test of the model coefficient revealed that the new model (with the explanatory variable included) is an improvement over the null model (chi-square = 322.838, DF = 7, $p < 0.000$). The overall Wald chi-square is significant which implies the explanatory variables are significant and add value to the model. The validity of the predicted probability relative to the actual, as stated in the classification table, is 75.3%. The Wald test regression coefficient for Dens_Pro ($p < 0.000$) and River_Pro ($p = 0.024$) is statistically significant; thus, we reject the null hypothesis that the regression coefficient is different from zero. However, for other independent variables ($p > 0.05$), we fail to reject the null hypothesis that the regression coefficients for explanatory variables are not different from zero, as revealed by the p-values of the Wald chi-square. The ODDS prediction equation for Pop_Dens: $e^{0.647} = 1.910$ indicating the high significance of slum and slum-like dense living for the prevalence of deprivation. The population density odds ratio indicated that the likelihood of being an informal settlement increases by 1.910 (nearly two times) for every addition of a settlement unit with a population > 12000 per kilometer square. The ODDS prediction equation

for Rive_Pro: $=e^{0.016} = 1.017$. The preceding prediction implies that the likelihood of being an informal settlement increases by 1.017 times with a one percent increase in river buffer area within a residential settlement unit, at a 99.994 percent confidence level. The Nagel Kerke R square revealed the improvement of the model and goodness of fit by 27.6 %.

Table 10 LRA analysis for settlement units' of 2010 residential settlement units (informal or formal) versus environmental features from 2013 and risk location from DTM

Predictor	B	SE β	Wald	df	P	Odds ratio (e^{β})
Constant	-0.488	9.255	0.003	1	0.958	0.614
Rive_Pro	0.016	0.007	5.070	1	0.024	1.017
Slop_Pro	0.004	0.003	1.910	1	0.167	1.010
Grop_Pro	0.049	0.093	.274	1	0.601	1.259
Buil_Pro	0.002	0.093	.000	1	0.982	1.201
Crop_Pro	0.040	0.093	0.187	1	0.666	1.249
Pop_Dens	0.647	0.136	22.775	1	0.000	1.910
Trve_Pro	0.024	0.093	0.066	1	0.797	1.228
Test						
			χ^2	df	P	
Model evaluation test						
Wald Test			283.876	1	0.000	
The Model Coefficient test						
The Omnibus test of model coefficient						
Chi-square			322.838	7	0.000	
Coefficient of determination						
Nagel Kerke R square	0.276					
Classification statistics						
Correct classified	75.3 %					
Delineated settlement unit	1521					

4.1.3.3. LRA analysis on settlement units (informal or formal) for 2022 versus environmental features (2021) and risk location (DTM)

The LRA is performed to analyze whether the existence of deprived settlements is explained by environmental features extracted from LULC, environmental health, and hazard locations (see table 11). Based on the analysis, the new model (with the explanatory variable included) is a better model than the null model, according to the results of the Omnibus test of the model coefficient (chi-square = 184.185, DF = 6, $p < 0.0001$). The explanatory variables are implied to

be important and contribute to the model by the fact that the Wald chi-square for the entire sample is significant. Yet, the Wald test regression coefficient for independent variables (Slop_Pro and Crop_Pro) is statistically different from zero ($p < 0.001$) and for Rive_Pro ($p < 0.003$). The ODDS prediction equation for Rive_Pro is $e^{0.023}$, equivalent to 1.023. The above result revealed that the likelihood of being an informal settlement increases by 1.023 times with a one percent increase in river buffer area within a residential settlement unit, at a 99.994 percent confidence level. The ODDS prediction equation for Slop_Pro is $e^{0.021}$, equals nearly 1.021. At a 99.999 percent confidence level, the result indicates that the likelihood of an informal settlement increases by 1.021 times with a 1% increase in slope area within a residential settlement unit. The ODDS prediction equation for Crop_Pro is $e^{0.167}$, which is equal to 1.182. The result indicates that the likelihood of being an informal settlement increases by 1.182 times with a one percent increase in crop area within a residential settlement unit. The validity of the predictive probability versus actual, as illustrated by the classification table, indicates that 66 % of the cases were correctly classified. The Nagel Kerke R square revealed the improvement of the model and goodness of fit by 19.2%.

Table 11 LRA for settlement units of 2022 residential settlement units (informal or formal) versus environmental features from 2021 and risk location from DTM

Predictor	β	SE β	Wald	df	P	Odds ratio (e^{β})
Constant	0.928	2.112	0.193	1	0.661	2.529
Rive_Pro	0.023	0.008	8.737	1	0.003	1.023
Slop_Pro	0.021	0.003	42.455	1	0.000	1.021
Grop_Pro	0.027	0.106	0.068	1	0.795	1.028
Buil_pro	-0.009	0.021	0.182	1	0.670	0.991
Crop_Pro	0.167	0.043	14.883	1	0.000	1.182
Pop_Dens	0.228	0.140	2.623	1	0.105	1.654
Trve_Pro	.864	1.073	0.648	1	0.421	2.372
Test						
			χ^2	df	P	
Model evaluation test						
Wald Test			122.048	1	0.000	
The model coefficient test						
The Omnibus test model coefficient			186.824	7	0.000	
Coefficient of determination						
Nagel Kerke R square	0.192					
Classification statistics						
Correct classified	65.9 %					
Delineated settlement unit	1252					

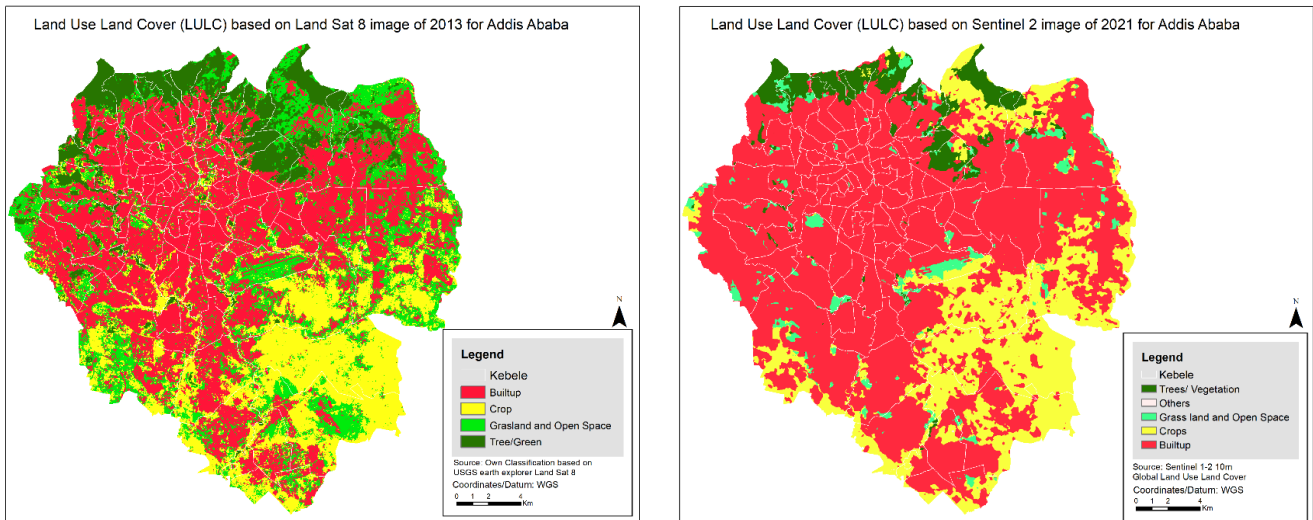


Figure 25 LULC of Addis Ababa city for 2013(own classification on Land Sat 8) and LULC for 2021 (ESRI LULC classification based on Sentinel 2 10m resolution)

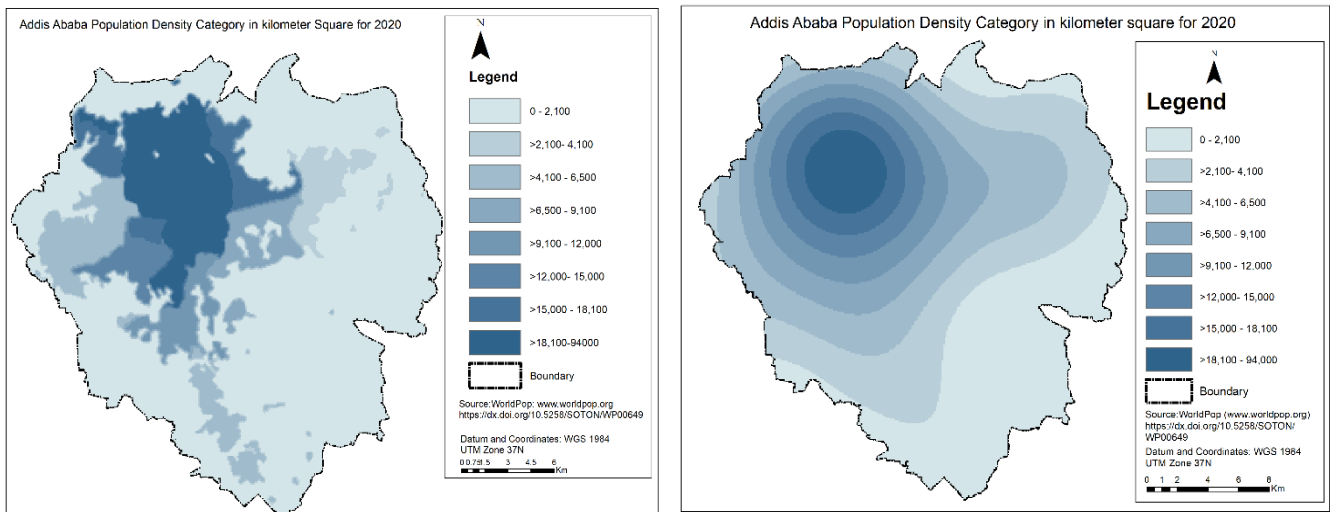


Figure 26 Population density in kilometer square for 2010 and 2020 based on the WorldPop for 2010 and 2020

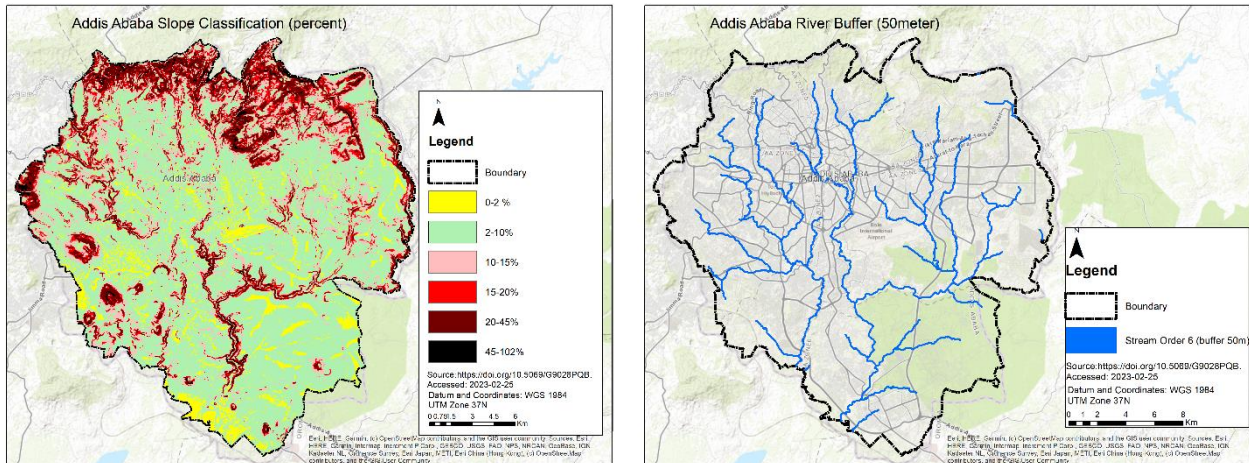


Figure 27 Addis Ababa slope classification in [percent(left) and River buffer 50 meter from stream order 6(right)

Table 12 the producer accuracy, user accuracy and Kappa coefficient for the classification of Landsat 8 2013

Class Value	Building	Crop	Tree or vegetation	Grassland and open space	Total	User accuracy	Kappa
Builtup	193	8	4	30	235	0.8213	0
Crops	6	93	4	5	108	0.8611	0
Tree/vegetation	0	0	52	2	54	0.9630	
Grassland and open space	6	8	1	88	103	0.8544	
Producer accuracy	0.9415	0.8532	0.8325	0.7040		0.8520	
					500		0.79

4.1.3.2. Settlement-based deprived area characteristics

Characterizing deprived and less deprived areas relies on the ontological framework: the intrinsic spatial characteristics and their interaction. The identified ontological framework was enhanced and validated by observations, a prior survey of informal settlement areas, and ground verification. The ontological properties of irregular road networks, tiny building sizes, and haphazard building orientations are the predominant characteristics of deprived residential areas (informal settlements). Informal settlements are disaggregated into slums, regularized informal settlements, and peri-urban informal settlements. The main rationale for informal settlement typology is due to settlement evolution, tenure, planning interventions, morphological

characteristics, location, and land use heterogeneity. The inner-city slum depicted old, dilapidated, dense, and small buildings crammed together in space, as well as a lack of local roads and right-of-way access for some residents, despite being interspersed with planned collector roads. A portion of the inner-city slum population also lives along a polluted river filled with excreta and waste, which emits an offensive odor. The inner-city slum houses are used for residential and mixed residential-use activities, while peri-urban houses are mostly used for residential purposes. The informal settlement is a continuous process as illegal additions ("kitiya") to the existing buildings are the most common practice in slum areas, while the once spontaneous settlements in the early stages of the settlement are consolidated with a new building in a peri-urban informal settlement. Regularized informal settlements have a mix of regular and irregular roads interspersed with a mix of standard and substandard buildings, displaying the landmarks of social gentrification. The peri-urban informal settlement has shown a pattern of spontaneously mushroomed buildings, irregular building and road layouts, absence of drainage, and unplanned open and green space. The peri-urban Informal settlement has shown a pattern of a small building with a relatively big undeveloped plot, while a parcel encompasses housings with different forms of tenure rights (kebele and permit rights) in central slum areas. Formal settlements have regular shapes and orientations of buildings and roads, as well as planned common areas—greenery and open spaces. The intermediate formal areas have more planned green spaces relative to formal settlements situated in the expansion areas.

4.1.3.3. The extent of deprived (informal settlement) and less deprived (formal settlement) areas

Informal settlement areas constituted 49.6% of residential land use in 2010 and 45.6% in 2022, which implies the informal settlement's absolute growth showed a 4% decline. The growth rates of Addis Ababa's informal and formal settlements between 2010 and 2022 were 2.68% and 4.56 percent, respectively. On the contrary, informal settlement areas in the four slum-dominated central sub-cities decreased by -0.106% per year between 2011 and 2022, owing to the effect of urban renewal on the area. Nonetheless, the formal settlement area for the four slum-dominated sub-cities has shown a sluggish increment of 0.793% in the intervening period. Yet, informal settlement annual growth rate is declining compared to 2010 informal areas for sub cities of Addis ketema, Arada and Chirkos. For other Addis Ababa sub-cities outside the inner-city slum sub-cities, the informal and formal settlement areas have increased by 3.51% and 4.87%, respectively. The high annual formal settlement growth trend for suburban sub-city areas is due

mainly to the large-scale housing projects and real estate housing development massively conducted in Addis Ababa in the intervening periods.

The informal area had shown a drastic annual growth increment surpassing formal settlement growth trends for the sub-cities of Nifas Silk, Kolfe Keranyo, and Yeka. Formal settlement has shown remarkable annual growth trends (17.35%) for Akaki Kaliti sub-city, followed by Arada sub-city (6.88%) and Bole sub-city (6.49%) between 2010 and 2022, which were 2.68% and 4.56%, respectively. On the contrary, informal settlements in the four slum-dominated central sub-cities decreased by -0.106% per year between 2011 and 2022, owing to the effect of urban renewal on the area (see table 13 for detail deprived and less deprived areas classifications).

Table 13 Informal (IN) and formal (FN) areas areal extent and change for AA sub-cities for 2010(aerial photograph) and 2022(Google image)

Subcity	2010 (Aerial photograph)				2022 (Google image)				2022-10 change (Gross ha)		The annual rate of change	
	FR (ha)	IN (ha)	RE (ha)	IN (%)	FR (ha)	IN (ha)	RE (ha)	IN (%)	FR (ha)	IN (ha)	FR (%)	IN (%)
Addis Ketema*	41	509	550	93	41	504	545	92	0	-5	0	-0.082
Lideta*	151	385	536	72	165	474	639	74	14	89	0.773	1.926
Arada*	23	533	556	96	42	483	525	92	19	-50	6.884	-0.782
Chirkos*	384	376	760	49	408	319	727	44	24	-57	0.521	-1.263
Akaki Kaliti	649	979	1628	60	2000	1108	3108	36	1351	129	17.347	1.098
Bole	2121	807	2928	28	3773	1152	4925	23	1652	345	6.491	3.563
Gulele	217	856	1073	80	229	864	1093	79	12	8	0.461	0.078
Kolfe Keraniyo	1593	1079	2672	40	1984	1488	3472	43	391	409	2.045	3.159
Nefas Silk Lafto	1658	1130	2788	41	2119	1919	4038	48	461	789	2.317	5.819
Yeka	1149	1190	2339	51	1599	2055	3654	56	450	865	3.264	6.057
Total	7986	7844	15830	50	12360	10366	22726	46	4374	2522	4.564	2.679
Central subcities*	599	1803	2402	75	656	1780	2436	73	57	-23	0.793	-0.106
Other Sub cities	7387	6041	13428	45	11704	8586	20290	42	4317	2545	4.870	3.511

Source: based on own delineation of formal and informal settlements of Addis Ababa

Nonetheless, the formal settlement area for the four slum-dominated sub-cities has shown a sluggish increment of 0.793% in the intervening period (57 hectare between 2010 and 2022). For other Addis Ababa sub-cities outside the inner-city slum sub-cities, the informal and formal settlement areas have increased by 3.511% and 4.87%, respectively. The high annual formal settlement growth trend for suburban sub-city areas is due mainly to the large-scale housing projects and real estate housing development massively conducted in Addis Ababa in the

intervening periods. Formal settlement has shown remarkable annual growth trends (17.347%) for Akaki Kaliti sub-city, followed by Arada sub-city (6.884%) and Bole sub-city (6.491%), due to a mix of condominium housing and real estate projects as well as private cooperative residential housing. Addis Ketema sub-city has shown only a 4-hectare decrement in informal settlement areas due to commercial building development since formal settlement areas have not shown change in the intervening periods (see figure 28 and 29 for formal and informal residential area maps for 2010 and 2022)

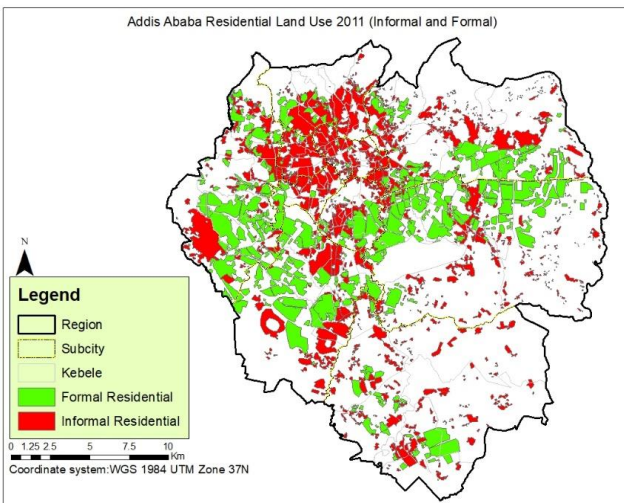


Figure 28 Net Residential Land use (Formal + Informal Residential only) Residential land use based on image interpretation supported with ground verification (2011 Aerial photograph)

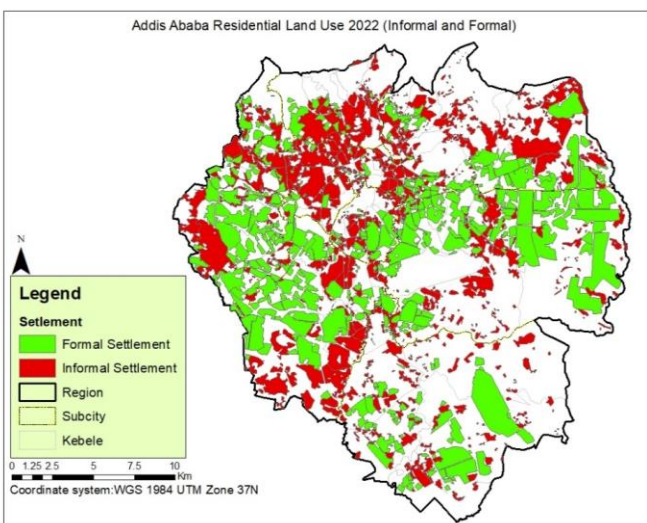


Figure 29 Net Residential land use (Formal + Informal residential only) based on image interpretation supported with ground verification (2022 google image)

4.1.3.4. Deprived Population estimate based on deprived area

The informal and formal settlement areas had an equivalent share in 2010—nearly 50 percent for both. In contrast, formal and informal settlement areas were 54 and 46 percent, respectively, in 2022. Based on the delineated settlement areas triangulated with point data at 100 meters by 100 meters for the worldpop gridded data, the search by location analysis in ArcGIS 8.4 revealed that in 2010, 68 percent and 32 percent of people lived in formal and informal settlements, respectively. The above result indicates that even if the area of formal and informal settlements were equivalent in 2010, more population is living in informal settlement areas, which needs further investigation of population density. Similarly, in 2020, the informal population is estimated to be 54% larger than the formal settlement population (46%). The above result indicated that even if the formal settlement area were larger, the proportion of the population living in informal settlements would still be higher (table 14).

Table 14 Formal and Informal population estimate based on gridded data for 2010 and 2020 population based on 2010 and 2020 formal and informal settlement area delineation.

Informal and Formal Population estimate for 2020 based on informal area of 2022					
Informal settlement Population	Formal settlement Population	Not captured population	Population (Gridded data)	Informal Population (Adjusted)	Formal Population (adjusted)
1258348	1082163	1065492	3406003	1831197	1574806
Informal and Formal Population estimate for 2010 based on informal and formal area of 2010					
Informal settlement Population	Formal Settlement Population	Not captured population	Population (Gridded data)	Informal Population (Adjusted)	Formal Population (adjusted)
1303605	617587	1371593	3,292,785	2234285	1058500
Annual Population growth rate (2010-2020)					
Informal settlement population	Formal settlement population	*Addis Ababa population (2020)			
-3.47 %	7.52 %	3,686,001			
*Not captured population means population not captured by informal and formal residential land use area in GIS search by location of gridded population data. This is due to the gridded population data located in non-residential land use of commercial, services and other non-residential land use.					
* Ethiopian Statistical Service (2021) population projection of CSA.					

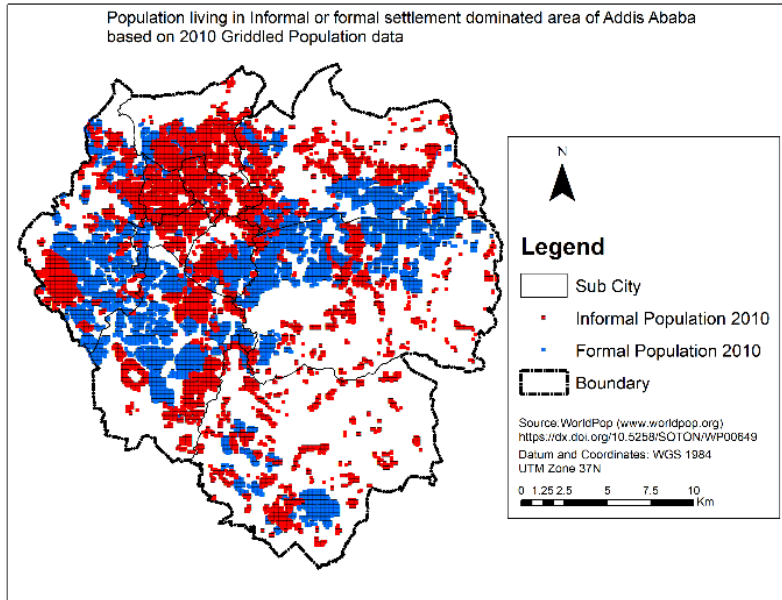


Figure 30 Population living in informal or formal settlement-dominated areas of Addis Ababa based on 2010 population-griddled data.

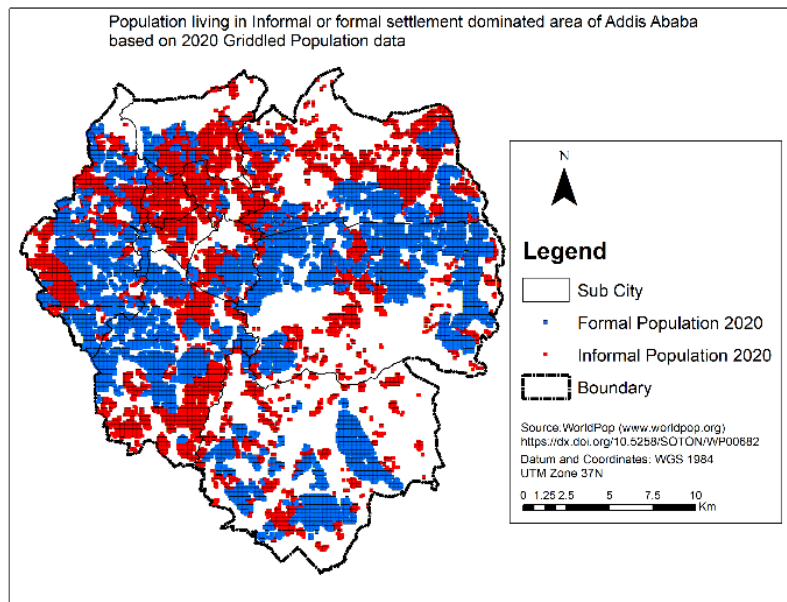


Figure 31 Population living in informal or formal settlement-dominated areas of Addis Ababa based on 2020 population-griddled data.

In addition, population density is computed for 2010 and 2020 for population points completely within or captured by formal and informal residential area polygons, delineated in Arcgis 10.8. The density and population estimate skip the population count in non-residential areas not captured by the delineated formal and informal residential areas. Thus, for 2010, Addis Ababa's jurisdiction had a population of 1,303,605 lying completely within an informal residential area polygon (7844 hectares). Thus, for informal settlements in 2010, the population density becomes 166 people per hectare. In a similar computation, for 2010, considering the population in the delineated formal area (617,587 people) and the formal area (6041 hectares), the population density for the formal settlement area was 102 people per hectare. Similarly, for 2020, Addis Ababa's jurisdiction had a 1,258,348-population lying completely within an informal residential area polygon (10,366 hectares). The population density for informal settlement in 2020 will be 121 people per hectare. Finally, for 2020, Addis Ababa's jurisdiction had 1,082,163 inhabitants lying completely within a formal residential polygon (12360 hectares). The formal population density for 2020 is 88 people per hectare. See figure 30 and 31 for population size captured in formal and informal settlement dominated polygon.

4.1.3.4. Analysis of deprivation for Addis Ababa selected areas at object level using deep learning

Addis Ketema sub-city object-based RF classification

The area depicts dense, interconnected, small-sized, and rusted corrugated iron sheets. The area has virtually no space for greenery and vegetation. The lack of right-of-way access for some residents is imperative due to the irregular and insufficient local roads extending to the residential population. The evaluation of the object-based classification results produced user accuracy, producer accuracy, and a kappa coefficient, as indicated in table 15. The light blue and silver-colored buildings are classified with high user and producer accuracy relative to others. In comparison to others, white-roofed buildings are produced with lower user accuracy due to the inclusion of other classes with similar reflectance and shape (especially roads and open spaces). Because objects that should be classified as roads and open spaces are instead classified as other classes, especially dark brown roofs, the producer accuracy for roads and open spaces is lower than the producer accuracy for other classes. The Kappa value of 0.78 indicates the result is at a substantial standard regarding the perfect agreement of the classification with ground truth.

Table 15 RF classification in ArcGIS Pro for Addis Ketema sub-city (informal settlement-dominated area)

	C11	C13	C14	C15	C16	C21	Total	User Accuracy	Kappa
C11	106	0	1	1	22	3	133	0.796992	0
C13	0	28	0	0	6	0	34	0.823529	
C14	1	0	23	0	12	1	37	0.621622	
C15	2	0	0	81	1	0	84	0.964286	
C16	19	1	2	2	115	3	142	0.809859	
C21	1	0	0	0	8	61	70	0.871429	
Total	129	29	26	84	164	68	500	0	
Producer Accuracy	0.821705	0.965517	0.884615	0.964286	0.70122	0.897059	0	0.828	
Kappa									0.780378

Source: C11(roofs dark brown), C13(roofs Red to light brown), C14 (Roofs white), C15 (Roofs Light blue and silver color buildings), C16 (road and open space), C21 (Green Areas)

The LULC of Addis Ketema sub-city constituted 741.27 hectares based on RF object-based classifications. From LULC, buildings, roads with open spaces, and green (grass and trees) constituted 52.32 percent, 33.72 percent, and 13.96 percent, respectively. The higher proportion of buildings in overall land use indicated how dense the inner-city slum is relative to other areas.

Table 16 RF object-based classification, area, and rectangularity for Addis Ketema sub city inner-city slum

OID	Object Name	Area(ha)	SI
1	Dark Brown Roof	160.562	1.742658
2	Light Blue to Silver Roof	125	1.578756
3	White Roof	54.9481	1.538929
4	Red to Light Brown Roof	47.3085	1.528907
	Sub-total	387.8195	1.597313
1	Light Dark Road and Open Space	249.983	1.655381
	Sub-total	249.983	1.655381
1	Green Areas	103.466	1.722713
	Sub-total	103.466	1.722713
	Total	741.27	1.658469

The dark brown roof color makes up 41.39 percent of the extracted roofs, an indicator of rusted corrugated iron sheet roofs, explaining the deteriorated nature of the old CBD slum buildings. The irregular white, light blue, and silver roofs are interspersed with dark brown roofs, indicating that new and previously maintained roofs have been installed to replace the old ones.

The small proportion of regular, compact shapes, and colors of the roofs in the area—white, light blue, silver, red, light brown, and others—indicate commercial, service, and formal residential buildings. From the colors of the building roofs, dark brown roofs clump together in space, making it difficult to segment and differentiate one building roof from the others. Furthermore, the high rectangularity index of dark brown roofs explains their irregular shape relative to other roofs. An area and shape index are presented for different colors of building roofs, roads, open spaces, and green areas, as indicated in table 16. See figure 32 for the overall morphological scenery of the area according to object-based RF classifications.

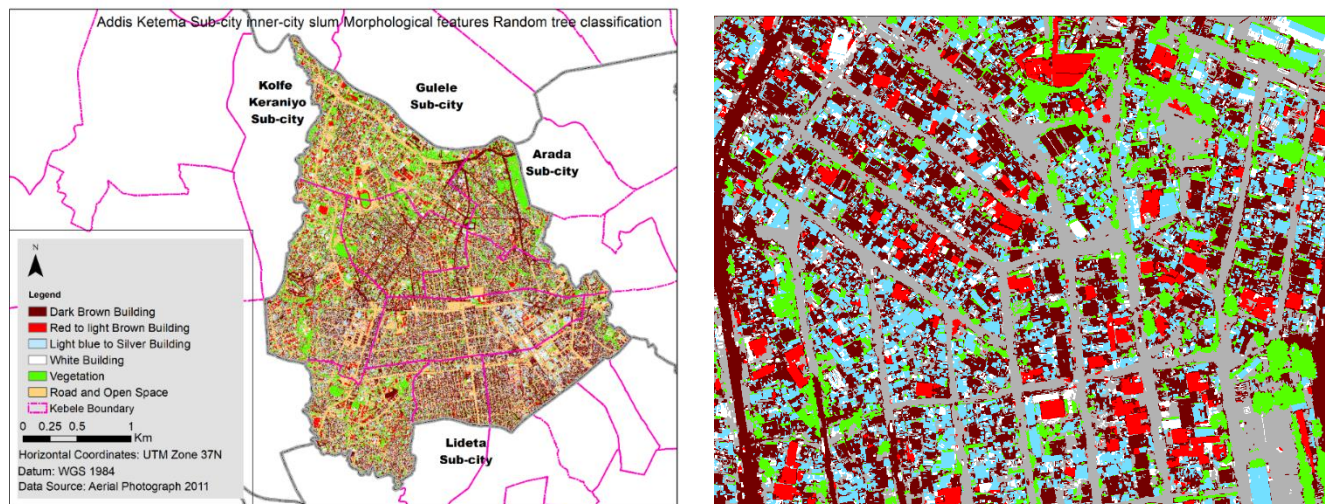


Figure 32 Addis Ketema sub-city inner city slum morphological Features RF classifications

Bole sub-city Kebele 11 object-based RF classification of Formal Settlement:

Building roof colors (red, light red, and medium brown) have higher user classification accuracy (> 0.9) relative to other categories. The finding suggested that roofs with representations of formal buildings had a reduced commission error rate. Buildings with dark brown roofs have poorer user and producer accuracy than other types. The dark brown roof user's accuracy is lower due to the erroneous inclusion of other classes (especially roads and open spaces with similar reflectance and shape) in the dark brown roof category. Omission mistakes in the reference pixel also lower the producer's accuracy for the dark brown roof. The producer's accuracy for trees, on the other hand, is higher, implying less omission error. The Kappa coefficient revealed that the classified image and the ground reality are almost perfectly aligned

for the intermediate formal settlement. The evaluation of the object-based classification produced user accuracy, producer accuracy, and a kappa coefficient, as indicated in table 17.

Table 17 RF classification in ArcGIS Pro for Bole sub-city Kebele 11 (Formal settlement-dominated area)

	C11	C12	C13	C14	C15	C16	C21	C22	Total	User Accuracy	Kappa
C11	22	0	0	0	1	1	0	0	24	0.916667	
C12	0	90	0	0	0	5	0	0	95	0.947368	
C13	0	0	10	0	0	0	0	0	10	1	
C14	1	1	0	11	0	1	0	0	14	0.785714	
C15	0	0	0	0	21	9	0	0	30	0.7	
C16	5	6	1	0	11	208	4	5	240	0.866667	
C21	0	0	0	0	0	0	11	1	12	0.916667	
C22	0	1	0	0	1	13	0	65	80	0.8125	
Total	28	98	11	11	34	237	15	71	505	0	
Producer Accuracy	0.785714	0.918367	0.909091	1	0.617647	0.877637	0.733333	0.915493	0	0.867327	
Kappa											0.813086
	Source: C11(red to light and medium brown building), C12(silver building), C13(blue to green building), c14(white to yellow building), C15(Dark brown building), C16(road and Open space), C21(grass) and C22(trees)										

Table 18 shows the result of the shape index for the classified objects as a measure of the regularity and compactness of impervious objects and permeable objects. The LULC of the Bole sub-city constituted 174.48 hectares based on RF object-based classifications. Buildings, grass and trees, and open space and roads accounted for 33.36%, 18.48%, and 48.16% of LULC, respectively. The majority (57.13 %) of the building roofs have a silver color. The formal section of the Bole sub-city has mixed functions and allows greater space for roads, open space, and green areas than the inner-city slum region, as seen from the above land use proportion.

The building roofs with colors such as red, light red, and medium brown seem less regular than the other roofs due to constituting most of the large, interconnected, and clumped roofs in the segmented image. On the contrary, the white-to-yellow roof shape depicts more regularity due to their being far apart at regular distances from each other.

Table 18 RF object-based classification, area, and rectangularity for Bole sub city kebele 11 Formal settlement

OID	Object Name	Area(ha)	SI
1	Dark Brown Roofs	10.27707	1.611171
2	Red, Light red, and medium Brown Roofs	8.424069	1.932277
3	Silver Roofs	33.259861	1.664522
4	Blue to Green Roofs	1.455141	1.490414
5	White to Yellow Roofs	4.786339	1.408888
	Sub-total	58.20248	1.621454
1	Trees	28.046793	1.786467
2	Grass	4.193698	1.455405
	Sub-total	32.24049	1.620936
1	Road and Open Space	84.039149	1.785492
	Sub-total	84.039149	1.785492
	Total	174.4821	1.675961

The green shape showed more regularity, even greater than most buildings, due to the regular, compact, rectangular green grass areas in the planned formal areas. The overall scenery of the permeable and impervious objects is illustrated in figure 33.

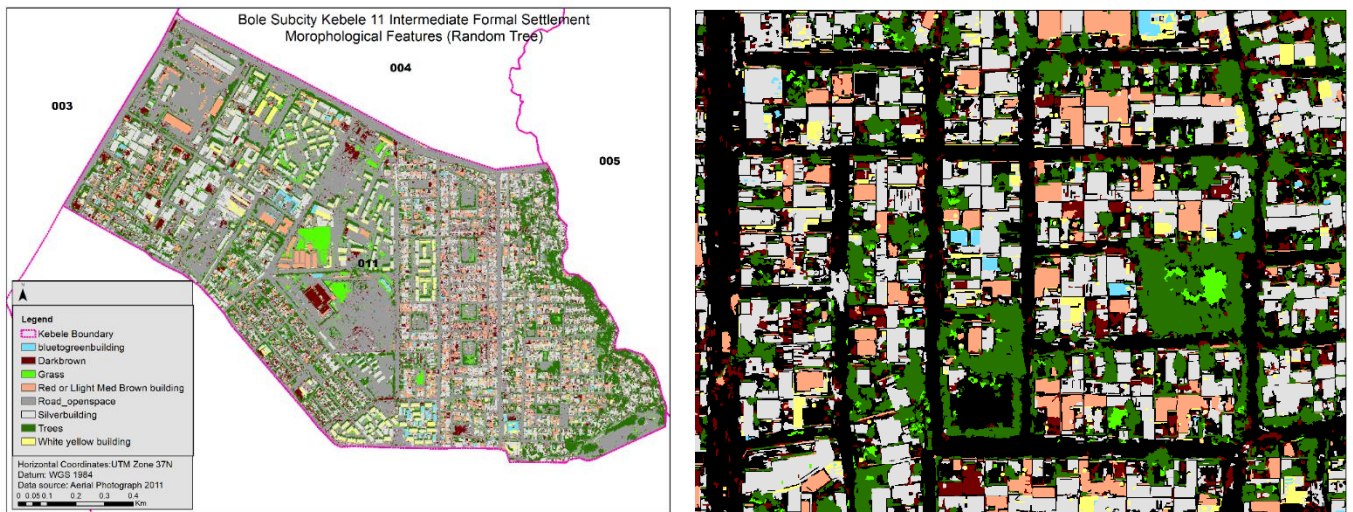


Figure 33 RF classification of building, road, and vegetation of Bole Kebele 11 (intermediate formal settlement)

Akaki Kaliti Kebele 07 object-based RF classification of peri-urban Settlement:

Crops are extracted with better user accuracy. Yet, the roofs, with colors ranging from light brown to dark brown, are extracted with very low user accuracy. In general, the lower user accuracy of peri-urban roof objects, especially very low for dark brown roofs, is because most open spaces and tilled land prepared for crop planting have similar pixel reflectance and shape to building roofs. The vegetation and trees have a higher producer's accuracy, which reveals fewer errors of omission, while the user's accuracy is not as high as the producers because of the similarity of pixel reflectance and shape with some of the crops. Nonetheless, roof colors ranging from light to dark blue are extracted with perfect producer accuracy and no errors or omissions. In peri-urban areas, most crops, vegetation, unpaved earthen roads, and open spaces have different shapes and colors, like building roofs, which lowers the user accuracy for building, especially dark brown roofs. The peri-urban area building size is small, as illustrated in Figure 34, like the inner-city slum. However, the small building is surrounded by a large fence or plot that separates the buildings, as well as the possession of large land for speculative gain. The vegetation was extracted with a higher producer's accuracy, while the user's accuracy is not as high, mainly because some of the crops responded with similar shapes and reflectance with vegetation. See table 19 for the resulting producers and use accuracy and a kappa coefficient.

Table 19 RF classification of building, road, and vegetation of Akaki Kaliti Kebele 07 peri-urban informal settlement

	C11	C12	C13	C14	C15	C21	C22	Total	User Accuracy	Kappa
C11	3	0	0	0	2	1	0	6	0.5	0
C12	0	5	0	0	5	0	0	10	0.5	0
C13	0	0	3	0	20	16	1	40	0.075	0
C14	0	0	0	5	0	4	1	10	0.5	0
C15	1	0	2	0	185	31	1	220	0.840909	0
C21	0	0	0	0	6	186	0	192	0.96875	0
C22	0	0	0	0	1	10	28	39	0.717949	0
Total	4	5	5	5	219	248	31	517	0	0
Producer Accuracy	0.75	1	0.6	1	0.844749	0.75	0.903226	0	0.802708	
Kappa										0.689727
Source: C11(White Building), C12(Silver Building), C13 (light to dark Brown Building), C14 (light to dark blue building), C15 (Road and Open space), C21 (Crop), C22 (trees/vegetation)										

The dominant roof color was white, which consists of 60.7 percent of the building's roof. The peri-urban informal houses' characteristics were small size, asymmetrical layout, and white roofs.

The Akaki Kaliti sub-city, Kebele 11, constituted 3141.92 hectares based on RF object-based classifications. Buildings, roads and open space, trees and vegetation, and crops accounted for 2.52%, 48.8%, 7.68%, and 40.99% of the LULC of the area, respectively. The above analysis indicated that peri-urban informal settlements were prevalent in open space and agriculture-dominated areas with premature statutory plan executions. The average shape index revealed that the building is more irregular, even surpassing the regularity index of other objects such as a crop, road, and open space. From the building, the white roof, a reflection of a new corrugated iron sheet, is more regular than others due to its newly constructed nature. An area and shape index are computed for different colors of buildings, roads, open spaces, and green areas, as indicated in table 20. See figure 34 for RF classification results for permeable and impervious surfaces object-based classification. The Kappa coefficient value is 0.69, which indicates the substantial agreement between the object-based classification and the ground truth.

Table 20 RF object-based classification, area and rectangularity for Akakai kaliti sub city Kebele 07 peri-urban

OID	Object Name	Area(ha)	SI
1	Light to dark Blue Building	0.377093	1.81166
2	Light to Dark Brown Building	23.288756	1.57799
3	Silver Building	7.493866	1.68141
4	White Building	48.147175	1.512616
	Sub-total	79.30689	1.645919
1	Road and Open Space	1533.473537	1.54789
	Sub-total	1533.473537	1.54789
1	Trees/Vegetation	241.398709	1.60568
	Sub-total	241.398709	1.60568
	Crop	1287.740297	1.59548
	Sub-total	1287.740297	1.59548
	Total	3141.919433	1.59874

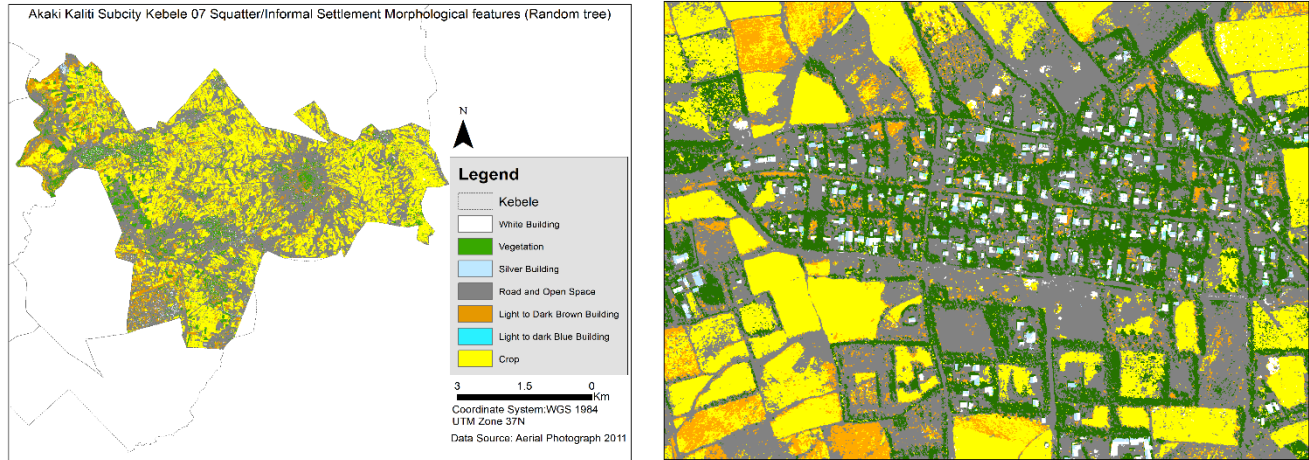


Figure 34 RF classification of building, road, and vegetation for Akaki Kaliti subcity Kebele 07 peri-urban

Kolfe Keranyo Kebele 02 object-based RF classification of expansion area formal settlement

In this part, roads, open spaces, and vegetation are extracted with better user accuracy, describing the quality of detecting impervious permeable features using GIS. In sum, buildings with roofs consisting of red, light brown, white, and silvery gray have higher user accuracy. The light blue roof color is produced with lower user accuracy since some of the predicted pixels for light blue were classified as silver-gray roofs, roads, and open spaces in the actual ground. Silver-gray building roofs were classified with greater user accuracy, followed by white roofs. Because some of the projected pixels were put in vegetation class, dark brown roofs had poorer user accuracy. For the "surfaces" of formal settlement expansion areas, producer accuracy reflects fewer omission errors. Yet, the producer's accuracy for blue and light blue roof buildings and green vegetation was greater than 98 percent. The kappa coefficient (0.85) indicates the perfect agreement between the object-based classification and the verification of the ground. As shown in Table 21, accuracy tools and a kappa coefficient were used to confirm the object-based classification reliability for categorized objects.

Table 21 RF classification of building, road, and vegetation of Kolfe Keranyo sub-city Kebele 02

	C11	C12	C13	C14	C15	C21	C22	Total	User Accuracy	Kappa
C11	7	0	2	0	0	0	1	10	0.7	0
C12	0	22	0	0	1	1	5	29	0.758621	
C13	0	0	53	1	2	0	1	57	0.929825	
C14	0	0	2	23	0	0	1	26	0.884615	
C15	0	1	0	1	34	0	17	53	0.641509	
C21	0	0	0	0	0	122	13	135	0.903704	
C22	0	1	1	0	2	1	192	197	0.974619	
Total	7	24	58	25	39	124	230	507		
Producer Accuracy	1	0.916667	0.913793	0.92	0.871795	0.983871	0.834783	0	0.893491	
Kappa										0.854535
	Source: C11(Building Blue and light blue), C12(building Red to light brown), C13 (Building Silver grey), C14 (White), C15 (Building Dark Brown), C21 (green Vegetation), C22 (Road and Open Space)									

Building roofs constituted 29.83% of the total, followed by roads, open space (43.2%), and vegetation (26.97%). The above land use indicated the mixed balance of land use and the availability of sufficient open space and green vegetation in the formal settlement expansion area. Silvery grey roofs accounted for 39.9% of building roofs, followed by dark brown roofs (25.1%), red to light brown roofs (17.9%), white roofs (17.4%), and blue to light blue roofs (2%). The figure depicts how the color of the building roof varies in formal settlement expansion areas. The regular and compact nature of the buildings is justified by the shape index, which is lower for buildings compared to other land uses. The extracted vegetation has a higher shape index, indicating morphological irregularity. In terms of building shape index, the blue to light blue roof building is more regular and compact, followed by the white roof, while the red to light brown roof depicts the most irregular shape. The road and space between buildings are more regular, reinforcing the formal nature of the area. See figure 35 for RF classification results for permeable and impervious surface morphological features and see table 22 for RF object-based classification, analysis of area and rectangularity.

Table 22 RF object-based classification, analysis of area and rectangularity

OID	Object Name	Area(ha)	SI
1	Blue to Light Blue roof	4.07072	1.1984
2	Dark Brown roof	51.7666	1.5898
3	Red to Light Brown roof	36.96264	1.626
4	Silver Grey Roof	77.37334	1.5937
5	White roof	35.9217	1.4195
	Sub-total building roof	206.095	1.48548
1	Road and Open Space	298.5045	1.5835
	Sub-total road and open space	298.5045	1.5835
1	Trees/Vegetation	186.3935	1.7065
	Sub-total vegetation	186.3935	1.7065
	Total	690.99	1.5918

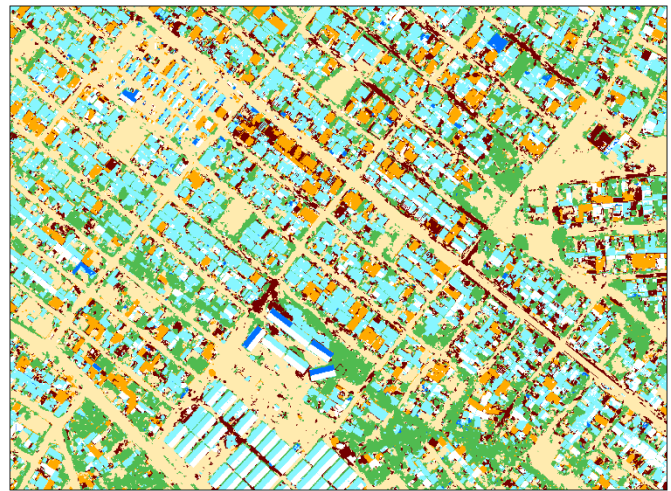
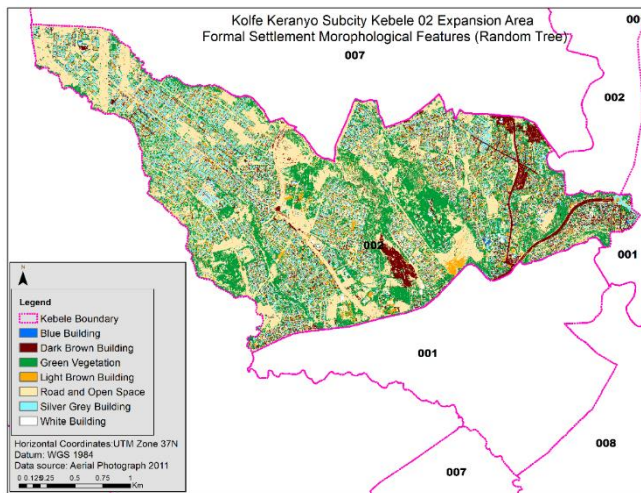


Figure 35 RF classification of building, road, and vegetation of Kolfe Keranyo Kebele 02 (expansion area formal settlement)

4.2. Discussions

4.2.1. The interrelationships of sustainable livelihood capital assets deprivations and asset based social policy interventions: The case of Addis Ababa informal settlement areas, Ethiopia.

The study used an explanatory sequential design, primarily analyzing through quantitative research, for refining strategic issues for ABS interventions that relate to many aspects of livelihood and capital asset deprivations, considering the variation among vulnerability sub-groups. Then, the qualitative individual case study reflected the depth of dwellers' impressions on their livelihood capital asset deprivations. The key informant interview analyzed the institutional, capability, and safety/risk issues. The triangulation of quantitative and qualitative information provided a comprehensive picture for validating the facts for ABS recommendations.

There is an interrelationship among livelihood capital assets (Farrington et al., 2002; Sheilah et al., 2001; UNDP, 2017). The greater the deprivation of livelihood capital assets, the greater the HHs risks and vulnerabilities following Lienert and Burger (2015). Financial capital is one of the crucial assets for capital accumulation and livelihood strategies, in line with the author's (Wang et al., 2021b) argument. Urban areas relied on a cash economy for food (61.36% and 55.8% for the inner-city slum and peri-urban, respectively). The peri-urban settlers spent more on water, transport, and energy for cooking (less than 9%) as compared with inner-city slum residents (less than 5%) due to social exclusion and non-integration with the mainstream of urban development. The above findings indicate that financial capital (cash, credit, and subsidies) is a strategic issue for livelihood capital asset accumulation. The reliance on the cash economy for food, water, transport, and consumables justified the underestimation of urban poverty relative to rural poverty, which conformed to the authors (Mitilin & Satterthwaite, 2004; World Bank, 2015b) argument. Thus, income, credit, and subsidy shall be integral parts of informal settlement interventions and poverty alleviations to realize sound livelihood capital asset accumulation and consolidation.

The findings of the inner-city slum revealed that income deprivation is associated with overcrowding, poor sanitation, substandard housing floor materials, and poor building quality. In the peri-urban setting, income deprivation is associated with going long distances to fetch water, low water consumption, low mobility, low parcel per capita, poor wall material, and poor building conditions. Regarding the interconnections within human capital, there is a difference in access to human capital by gender and educational status. Gender and income do not show a significant association in informal settlements, according to Jayamohan and Amenu's (2014) argument. Yet, regarding human capital, women are deprived of occupation (85% of HHs depended on assistance were widowed FHHs in the inner-city slum) and educational status (2.15 and 1.77 illiterate FHHs for every MHHs in the inner-city slum and peri-urban, respectively). The vulnerability of the old-age HHs to poverty interfaces with the author's (Aboderin et al., 2017) arguments for an age-friendly slum initiative as the older people are cohabiting with and caring for children.

The overall unemployment rate of the inner-city slums (33.71%) exceeded the unemployment rate of 28.6% for the 15–64 age groups in Addis Ababa (CSA, 2015). Moreover, the youth unemployment percentage was associated with the education status of grades 9–10 in the two informal settlement areas ($r \geq 0.3$). The unemployment findings conform to FDRE (2018), which implicated creating job opportunities for youths of secondary education level and orchestrating the curriculum and competencies to be job oriented. Unemployment is a strategic issue since a higher unemployment rate is significantly associated with overcrowded living conditions, low educational status, and low income. Moreover, the poor HHs education status leads to family members' poor education status in line with the culture of poverty theory of Lewis (1966). The lesson is that poverty alleviation programs shall enhance the class-consciousness of parents of low education levels through informal/adult education, as it is a strategic issue.

Overcrowding is the strategic issue in the inner-city slums; related to low income, the unemployment rate, and poor sanitation. Hence, overcrowding, through renting beds, is the survival strategy for diversifying sources of financial capital by the inner-city slum dwellers, based on key informant interview findings and the quantitative information (39.3% of HHs survived through renting beds). The above situation depicts Alonso-Muth's Mills bid for rent

model argued by UN-Habitat (2003a) that the poor outbid the rich for CBD through overcrowding, renting, and reducing mobility.

Tenure security is the strategic entry point for livelihood capital asset accumulations due to a link between SDG goal 1 on poverty reduction and goal 11 indicators of addressing inadequate housing, slums, and access to land in line with SDG Tracker (2019). Tenure-insecure HHs in the inner-city slum is vulnerable to poor sanitation, poor water access, and low income. Most HHs in peri-urban areas (82%) were tenure insecure and associated with poor sanitation services. The inner-city slum and peri-urban findings indicated an association between tenure security levels and CBO. CBO is a potential local organization for enhancing community bargaining potential with government and developers. Therefore, asset accession through direct regularization is advantageous for unlocking dead capital in the property market and bargaining means for credit, collateral, and service provision (Dani & Moser, 2008; De Soto, 2001; Fontana, 2016). Yet, contrary to the above authors, direct regularization encourages land speculators, the transaction of property by new privileged right holders, and exorbitant rent for renters. For instance, the legally recognized tenure groups (permit rights holders and Kebele renters) in the inner-city slum rented their houses for exorbitant prices relative to the very low rental price paid by Kebele renters to the formal Kebele administration. Thus, full titling (non-incremental regularization) could lead to exorbitant rent for renters and market-based eviction for owners (transacting property for a better price by owners) due to neighborhood improvements (Payne et al., 2009). Group and occupancy tenure rights provision for HHs with no tenure right with a long time span paves the way for incremental regularization to lease or other forms of rights in the future and discourages land speculators, as articulated in Payne et al. (2009).

The poor HHs in the inner-city slum that dwell in the edges of watercourses and on the sides of steep slopes tend to be more vulnerable to a lack of mainstream infrastructure and services (road access, sanitation, water, drainage) in general. In addition, they are also vulnerable to environmental hazards (recurrent floods, landslides, toilet overflow, poor refuse collection, water pollution, transmitted diseases, and so on) and crime (safety and security). In addition to suffering from similar problems to a considerable degree, peri-urban HHs lives in high-slope and marginalized areas lacking critical infrastructure (motorable roads, water mains, power and communication grids, health facilities, and shopping services) and are liable to crime. The asset derived from natural capital (the river) for the inner-city slum, is polluted with human waste and

excreta through direct toilet connections that adversely affect the health of human capital. The peri-urban informal settlements live on risky, steep slopes, exposed to flooding and landslide hazards. In general, to accumulate livelihood capital for poverty alleviation, informal settlement areas need interventions to enhance their resident's resilience to disaster, economic shock, and stress.

The peri-urban institutions mobilize meager social capital, and fewer institutions work to access and control assets by subgroups. The peri-urban subcity and Wereda institutions do not involve civic society associations, except CBO. They are also not partners with private organizations and NGOs for accessing livelihood capital assets for the poor and vulnerable subgroups, as the predominantly peri-urban informal settlements are less integrated in development and poverty alleviation activities. The inner-city slum institutions relatively mobilized the potential of human capital assets by formulating civic society associations, NGOs, and private organizations while failing to utilize CBO for livelihood capital asset accumulation. The inaccessibility of enabling institutions and social capital to enhance their asset base, especially pronounced in peri-urban areas, exacerbates poverty, brings social injustice, and limits access to credit and labor for the poor, considering the authors (Bebbington, n.d.; Dani & Moser, 2008; Sen, 1995; Serrat, 2017; Shahbaz et al., 2010; UNDP, 2017) argument.

The imposition of high-standard building permit regulations (mostly G + 7) on the inner-city slums eroded the livelihood capital accumulation and valorization for the poor through incremental housing improvement. The above regulation is evidence that the poor have little political clout, negotiation, and bargaining power in their own residential areas. The power of the decision is in the hands of political elites in the high-value areas of CBD (Central Business District) maneuvered by developers, and political elites conform to Logan's (1976) growth machine theory. For peri-urban, the government recognized *de jure* tenure rights for farmers while excluding HHs, who bought land from farmers, which contravenes the global trend of leaving no one behind in informal settlement regularization and upgrading following UN-Habitat (2020b).

The government enhanced the job creation capability of the unemployed and the functioning of that capability through MSSE development, revolving funds (the inner-city slum and peri-urban areas), and asset-based lending for machinery (the inner-city slum). Traditional collateral funding poses a challenge for the financial recovery of firms and the sustained functioning of the

poor to work on their capabilities and resources. Therefore, expansion of asset-based lending and a special fund allotment for MSSE are the alternative options in line with the authors (Nega & Edris, 2016), backed with training, diverse sources of financing MSSE', and a robust management system for revolving fund recovery. The inner-city slum has relatively better capability functioning, considering the mobilized social and human livelihood capital assets in relation to the peri-urban, following the authors' (Lienert & Burger, 2015) argument regarding asset and capability. UPSNP contributed to asset accumulation by involving the poor in public works, reducing environmental risks, enhancing savings and creditworthiness, upgrading individual skills, and involving the beneficiaries in work they can be and do and capital asset accession.

In accordance with asset theory of social preference (Iverson & Soskice 2001), to reduce poverty for informal settlement dwellers, the poor HHs with low skill and capital require insurance against future loss of income and asset erosion. Based on current reality, UPSNP and other partner organizations shall be sustainable in realizing asset consolidation for the chronically poor population through integrating revolving fund injection, low-interest rates, asset-based lending, and tenure security. In sum, informal settlements required addressing the capability deprivations of the poor, preventing asset erosion, and accessing vulnerable sub-groups with livelihood capital through mobilization of the community, civic society, and other partner multilateral and bilateral institutions, following the authors (Bebbington, n.d.; Dani & Moser, 2008; Sen, 1995; Serrat, 2017; Shahbaz et al., 2010; UNDP, 2017) argument.

Moreover, urban development policies and strategies need revisiting and fine-tuning to address the chronically poor following Kassahun and Tiwari (2012), and the existing policies need orchestration in line with ABS on how to prevent asset erosion for the poor consistency to ultimately achieve asset consolidation. The new trend in social policy shall bring transformational change through the principles of universality, inclusion, integration, and partnership aligned with global and regional social policy following the United Nations (2021).

4.2.2. The Spatial Pattern of Deprivations and inequality: The Case of Addis Ababa, Ethiopia

4.2.2.1. Overview of MDI 2007 and MDI 2016: Inductively Derived PCA Analysis and Spatial Pattern

The MDI 2007 and the MDI 2016 discussed the findings of the first and second research questions in combination by triangulating the pattern of PCA-derived indicators and components with the pattern obtained from the spatial pattern of components. The study also triangulates the findings with SDG, theoretical, and empirical frameworks. For MDI 2007, the result indicated that the first and second components were the main ones, constituting 67.2 percent of the variations in the original dataset, while the third and fourth components explained only 14 percent. For MDI 2016, three of the components explained 60% of the variation in the original data set, with no drastic differences in the percentage of variance explained by the three components. The MDI 2007 and MDI 2016 developments indicate that poverty is multidimensional and multifaceted (Townsend, 1979; Turkstra, 2004; Mitilin & Satterthwaite, 2004). The persistence of low education levels and a high proportion of illiterate HHs (Households) as a critical component of the MDI in 2007 and 2016 implied that much work needed to be done to improve informal parental education as well as the overall quality of education to reduce the negative and transgenerational effects of poverty traps (Crane & Manville, 2008). Education level is associated with income, housing inadequacy, unemployment or poorly paid jobs, and poor infrastructure, which rationalizes achieving sustainable urbanization by linking SDG goals 1, 4, 8, and 11. The MDI 2007 and 2016 both revealed a link between vulnerability and deprivation (Berthoud, 1983; Wong, 2001; Whelan & Maître, 2005; Yuan & Fulong, 2014; Qiu et al., 2022), implying that the MDI should be used to target resources, green space, and infrastructure to socially excluded and vulnerable groups in order to meet SDGs 1 and 11.

Deprivation is associated with the urban form of Ethiopia, as it is higher in declining inner-city and peri-urban informal settlements while it is lower in intermediate and suburban planned and new development regions (Tesfaye, 2019). Thus, deprivations can be studied based on the urban morphology of formal and informal settlement. The overlaps of correlated indicators and components over space using PCA and the facts of spatial inequality based on spatial

autocorrelation analysis reinforce the necessity of place-based compensatory policy (Smith, 1999; Tunstall & Lupton, 2003; Crane & Manville, 2008; Turok, 2013; Hohmann, 2014; Sabine et al., 2021). An area-based policy is justified for Addis Ababa due to a high annual rate of urbanization, a divided city, informal settlement problems, and a housing supply shortage (Turok, 2013; MUDH [Ministry of Urban Development and Housing], 2015; World Bank Group and Cities Alliance, 2015; Habitat for Humanity Great Britain, 2017; Wahba & Ranarifidy, 2018). The MDI is helpful for tracking the indicators and extent of problems related to SDG 11's housing inadequacy (SDG Tracker, 2019; Patel, Shah, Beauregard; 2020), based on the findings of the 2007 MDI.

4.2.2.2. Overview of MDI 2007 component 1 (LHSS): PCA and Spatial pattern analysis

This component explained the overlaps and coexistence of a high proportion of substandard housing materials and limited access to services (water, sanitation, waste disposal, cooking, and electricity). In addition, this component also explained inadequate housing facilities and low human capital assets (low educational status, high illiteracy, and a higher number of young dependents). In sum, this component reflected the most pervasive problems common to large parts of Addis Ababa's informal settlements. Because of the dominance of substandard housing, poor services, and facilities, the use of MDI for urban regeneration and prioritization (Coombes and Raybould, 1989; Andrea, 2012; McLennan, n.d) is rationalized. Therefore, there should be a trend to capture a multitude of problems rather than focusing on some specific criteria not supported by MDI tools, learning from Addis Ababa's slum upgrading experience (Tesfay, 2016). The higher proportion of people with lower education and young dependents reflects the typical character of the Ethiopian poor (World Bank Group, 2020b). Yet, the relatively lower electricity provision for this component (LHSS) relative to the second component (HEPSV) indicates that this component reflects the largely suburban and peri-urban informal settlement features. Deprivation is concentrated, based on the LISA H-H relation, in the outskirts, central, and southern suburban informal settlements. Therefore, this component reflected the features of informal settlements outside the inner-city slum.

Yet, the L-L relationship of LISA is depicted in some neighborhoods of the old cultural and education center (piazza) established by the Italian colony (Arada sub-city) and modern formal

settlement neighborhood units in the sub-cities of Bole, Chirkos, and Yeka. The SDG 11 housing inadequacy indicators (poor sanitation service, poor water service, and poor housing durability) had a high loading score for this component; therefore, the housing inadequacy indicator of the SDG reflected most of the Addis Ababa informal settlements (SDG, 2018). In addition to the SDG slum indicators, high-loading score indicators such as low educational capital assets and deficient housing facilities are potential indicators for informal settlements. Because poor education and inadequate housing are overlapping indicators, it makes sense to combine SDGs 4 and 11 for addressing human and physical capital asset deprivation.

4.2.2.3. MDI 2007 Component 2 (HEPSV) PCA Analysis and Spatial Pattern

This component has a strong positive global spatial autocorrelation, explaining that the inner-city slum is an area of concentrated and polarized poverty. This component showed overlaps and coexistence of a high proportion of older housing, deprived private tenure rights (renters), overcrowded living, a dense population, a high proportion of disabilities, and the unemployed. Based on the above fact, this component witnessed the clustering of the most vulnerable dwellers and renters living in aging dwellings. On the contrary, most houses had a high proportion of electricity and waste disposal services (CSA, 2007) due to their inner-city location. The characteristic of a high proportion of old buildings, degenerating housing and infrastructure, and the most vulnerable sub-group, reflects the typical inner-city slum features (Elias, 2008; UN-Habitat, 2015; UN-Habitat, 2017; Habitat for Humanity Great Britain, 2017). The SDG indicators (overcrowding and private tenure owner right deprivations) had a higher loading score for this component, which reinforces the inner-city slum nature of this component (Elias, 2008; UN-Habitat, 2015; UN-Habitat, 2017). For this component, a high proportion of renters, older houses, and substandard dwellings justify the preponderance of dilapidated and old kebele and municipal rental dwellings in inner-city slums (Elias, 2008). In addition, the MDI 2007 component 2 (HEPSV) has high positive loading scores for the widowed or divorced FHHs and disabled population proportions. The above result explained the association of multiple deprivation indicators with the concentration of socially excluded and vulnerable groups (Berthoud, 1983; Wong, 2001; Yuan & Fulong, 2014). Moreover, the concentration of FHH widows or divorcees in the urban core, in line with social organization theory (Wong, 2001), implicates the necessity of gender and marital status mainstreaming interventions. The high proportion of unemployed people in the inner-city slum indicates the economically vulnerable

subgroups were the most exposed to multiple deprivations (Whelan & Maître, 2005). The spatial pattern based on the LISA map confirmed that the high deprivation area is concentrated in the inner-city slum areas, aligning with the inductively derived and discussed PCA pattern for characterizing inner-city slums. Low-deprivation areas were concentrated in the suburban formal settlement sub-city areas.

4.2.2.4. MDI 2007 Component 3 (VUSG) PCA Analysis and Spatial Pattern

This component revealed the coexistence of vulnerable social groups (old dependents, migrants, widowed or divorced FHHs, illiterate), aged buildings, substandard housing walls, less access to electricity, and bathing facilities. This component indicator partly reflects inner-city slum characteristics (old dependents, aged buildings, vulnerable female HHs, and substandard housing materials). In addition, this component indicates characteristics of informal settlements outside the inner-city slum (a high proportion of migrants, a lack of electric services, and substandard housing materials). Similarly, the LISA H-H pattern revealed deprivation clustering in inner-city slums and peri-urban areas. The peri-urban informal settlements are the main repository for rural-urban migrants (Elias, 2008; Bundervoet, 2018; Abagissa, 2019; Berhanu et al., 2022) and are furnished with little or no electricity. Furthermore, the LISA revealed a high concentration of deprivation in inner-city areas, reflecting the repository of recent and temporarily migrants, old buildings, and vulnerable groups in the inner-city areas (Turner, 1976). The empirical frameworks also mentioned the existence of inner-city illegal housing construction in Addis Ababa (Elias, 2008; Issa, 2021), who are mainly migrants. Additionally, a sizable portion of slum residents who resided close to the old CBD rented beds (Berhanu et al., 2022) in overcrowded rooms for temporary and recent migrants.

4.2.2.5. MDI 2007 Component 4 (PHSC) PCA Analysis and Spatial Pattern

This component reflected houses deprived of kitchens in informal settlements due to space shortages for separate kitchens as well as areas deprived of electricity. According to the spatial pattern depicted by the LISA H-H relation, this component showed high deprivation clustering in the inner-city slum areas and the southern and eastern fringe informal settlement areas of Addis Ababa. Yet, the LISA L-L clustering was depicted in the northern and western mixed (formal and informal) settlement areas of Addis Ababa. Based on the 2018 survey conducted in peri-

urban and the inner-city slum- areas of this research, 60% and 40% of the selected peri-urban and inner-city slum housings do not have kitchens, respectively.

4.2.2.6. MDI 2016 Component 1 (CLVS) PCA Analysis and Spatial Pattern

This component indicated the reinforcing and overlapping nature of deprivations based on indicators of high population density, high building density, widowed or divorced FHHs, older HHs, and unemployed HHs. The first component indicated the overcrowded living conditions of vulnerable sub-groups. The findings implied that Addis Ababa's inner-city slums are characterized by the area of concentration of the most vulnerable sub-groups living in overcrowded conditions (UN-Habitat, 2015; UN-Habitat, 2017; Habitat for Humanity Great Britain, 2017). Similarly, the spatial pattern of LISA H-H clustering revealed that the vulnerable social groups with high overcrowding were clustered in purely inner-city slum areas. The LISA L-L clustering was depicted in the peripheral mixed-settlement neighborhoods in the western fringe areas and the new formal settlement development areas of Addis Ababa.

4.2.2.7. MDI 2016 Component 2 (LSES) PCA Analysis and Spatial Pattern

The second component of MDI 2016 (LSES) explains how low income reinforces low human capital assets (high proportion of HH illiteracy, low higher education level, and low-paying self-employed jobs). The above finding justifies the link between SDGs 1, 4, and 8. This is due to education being a means to reduce poverty by increasing people's income (Vladimirova & Le Blanc, 2015) and providing employment opportunities. The finding also implies that economic vulnerability reinforces multiple deprivations (Gordon, 1995; Whelan & Maître, 2005). The PCA findings implicate the rationality of developing MDI from monetary and non-monetary indicators (Gordon, 1995, Martinez, 2005) since they are mutually reinforcing each other. The LISA H-H revealed how low socio-economic status and deprivation were created due to low human and financial capital assets. Because of the LISA L-L relationship, deprivation showed low clustering in formal neighborhoods, where most dwellers have high socioeconomic status.

4.2.2.8. MDI 2016 Component 3 (EVIN) PCA Analysis and Spatial Pattern

This component indicates that overcrowded places, in terms of population and building density, are less endowed with green and road infrastructure per capita. The above result confirmed the finding that slums in Addis Ababa are places disengaged from infrastructure and public space/greenery (UN-Habitat, 2015; UN-Habitat, 2017; Habitat for Humanity Great Britain, 2017). Yet, the less crowded areas, which are better endowed with green space and road infrastructure, are a feature of Addis Ababa's less developed outskirts. The result also justified the rationality of SDG target 11.7 for providing access to green and public open spaces for vulnerable groups (SDG, 2018). Additionally, morphological characteristics extracted from satellite images are powerful indicators of deprivation (Baud et al, 2010; Ajami et al., 2019).

4.2.2.9. Population Proportion and Density versus Deprivation

In line with the third and fourth research questions, the study analyzes and interprets the proportion of the most deprived population for MDI 2007 and MDI 2016, the correlations and spatial relationships between deprivation and population density, and then suggests the implications for area-based policy. The most deprived populations of Addis Ababa were 68% for MDI 2007 and 33% for MDI 2016. Deprivations have shown declining trends in most sub-cities; however, the inner-city slum sub-cities of Addis Ketema and Lideta remained in VHD for MDI 2007 and MDI 2016 as well. Similarly, HD also declined in proportion for most sub-cities, except for the inner-city slum sub-cities of Lideta and Arada. For the Kolfe Keranyo sub-city, the most deprived population declined from 62% for MDI 2007 to 0% for MDI 2016. The decline is due to the new, formal-dominated settlement that emerged over the course of the two MDI years.

Other than population proportion, other aspects of urbanization, such as migration and population density, explained concentrated poverty. Regarding density, the PPMC results explicitly indicated that deprivation increased with increasing population density, and the result justified how the density of the poor population definition describes concentrated poverty (Murray, 2015). In addition, there is a spatial relationship between deprivations, population density, and urban form. For MDI 2007 and MDI 2016, deprivation reaches a peak in the old CBD area, with a progressive decline in the intermediate areas and rising again in the peri-urban

area. In the old CBD area, population density increased along with the deprivation score for MDI 2007 and MDI 2016. Based on the spatial profile trends, the high deprivation score and population density near and around the old CBD align with the inner-city radius of 4.5 km from the main CBD (Weldeghebrael, 2022). In peri-urban areas, deprivation increased as population density decreased. The spatial profile indicated how deprivation trends varied with the Ethiopian urban form (Tesfaye, 2019), as well as a vivid picture of deprivation polarization and a divided city pattern and the rationales for implementing area-based policy (Turok, 2013). The threshold area of deprivation in the CBD expanded for MDI 2016, relative to MDI 2007, substantiating the overcrowding and consolidation of the inner-city slum population and density (CSA, 2013; Weldeghebrael, 2022).

The high deprivation score in the peri-urban area conforms to Alonso's "bid rent model", which suggests that the poor housing and buildings lie in the affordable outskirts area (Shieh, 2003). The increasing deprivation in the fringe area, based on the deprivation profile graph, aligns with Addis Ababa's peri-urban informal settlement characteristics and locations (Elias, 2008; Bundervoet, 2018; Abagissa, 2019; Berhanu et al., 2022). Even if the old CBD of the inner city's large population concentration replicated Alonso's "bid rent" model (Narvaez et al., 2013), the inner city is a repository of poor populations living in dense quarters. Deprivations increased with increasing rural-urban migrants in peri-urban areas (CSA, 2007; Bundervoet, 2018; CSA, 2021; Berhanu et al., 2022), as well as consolidated, partly through bed rent and illegal building construction (*meteleya*) of migrants, in inner-city slums (Berhanu et al., 2022; Issa, 2021). The findings indicated that the old inner-city slum of Addis Ababa is a concentrated poverty area that conforms to the global north theoretical lens (Wilson, 1987). Nonetheless, except for areas affected by renewal interventions (Kloosterboer, 2019), Addis Ababa's inner-city slum was not affected by the global north's deindustrialization and suburbanization of urban jobs in accordance with the theoretical framework of concentrated poverty in America (Wilson, 1987).

The relationship between the spatial distribution of deprivation and population size and density rationalized the development of tools for better targeting concentrated poverty. The MDI is rational for better targeting and prioritizing since sector-based pro-poor spending does not fully benefit the vulnerable and poor population, based on the evaluation of 122 World Bank poverty-targeted social programs (Van Domelen, 2007). Moreover, the high proportion of vulnerable

people, including elders, persons with disabilities, females, and the unemployed, implicated a policy framework and tools for better targeting and budget rationing for people needing social protection to realize SDG 1 (SDG, 2018; World Bank, 2022). In summary, a disaggregated area-based welfare policy is an essential intervention (Smith, 1999; Debebe & Zekarias, 2020; Bigman & Fofack 2019; Patel, Shah, Beauregard; 2020) to benefit the disadvantaged and vulnerable population, addressing slum problems and decrease the polarization of poverty.

4.2.3. Deprivations patterns from urban morphology perspectives: the case of Addis Ababa, Ethiopia

4.2.3.1. Informal settlement growth and trends: 2010 and 2022

Informal settlements have dropped slightly, by 4%, between 2010 and 2022. Though sluggish, the preceding declining trends corresponded with global trends of informal settlement decline (UN-Habitat and Global Urban Observatory 2019). The urban renewal interventions (Zewdie et al., 2021; Weldegebriel et al., 2021) are the reason for a minor drop in the informal settlements' growth rate in the pure inner-city slum (-0.106%), while the formal settlements have shown a slight increase (0.793). Nevertheless, the formal as well as informal settlements, located outside the pure inner-city slum sub-cities, have shown reasonable growth. The construction of large-scale condominium houses, real estate housing, and the relocation of dwellers from the city center due to urban renewal are the justifications for the formal settlement increase in the suburban area currently (Zewdie et al., 2021; Weldegebriel et al., 2021). Yet, despite the average annual formal settlement growth trends relative to informal, the suburban informal settlement annual growth rate has surpassed formal settlement growth trends for 2010–22 for the sub-cities of Nifas Silk, Kolfe Keranyo, and Yeka, reflecting Hamza's (2023) review of suburban informal settlement growth in Ethiopian urban centers despite consistent demolition. To summarize, the general trend in Addis Ababa City is that formal settlement growth has outpaced informal settlement growth by 1.89% per year. The overall formal settlement growth corresponded with the annual urbanization growth rate for Addis Ababa (World Bank Group and Cities Alliance, 2015), which indicates that currently urbanization in Addis Ababa is driven by formal settlement growth. In 2010, even though the area per hectare is almost similar for formal and informal settlements, the population living in informal settlements was 68 percent, and the informal

settlement population density was 166 people per hectare. In comparison to the 44% informal settlement area assessed by the World Bank (2008), Addis Ababa's area for informal settlement of 2010 (50%) has exhibited a 6% increase. According to the World Bank (2008), 66% of people reside in informal settlements. However, the estimate of the population in this study based on the informal area was 68% in 2010, which implied a 2 % increase of informal settlement in 2010 as compared with World Bank (2008).

The population density result for 2010 (166 people per hectare) is slightly higher than the 2007 average density estimates (160 people per hectare) for Addis Ababa by AACPPO (2017). The above-triangulated result revealed the overcrowded nature of informal settlements, especially inner-city slums, in the past decades (UN-Habitat, 2017; Elias, 2008; Habitat for Humanity Great Britain, 2017; UN-Habitat, 2017). Yet, in 2020, the proportion of the population living in informal settlements declined to 54 percent, and the population density became 121 people per hectare. The informal settlement density result for 2020 is lower than the average Addis Ababa city density estimate for 2016 (190 people per hectare) by AACPPO (2017). The above result further indicates that the once-important role of high population density as a driving force of informal settlement (deprived areas) in the past decade is declining in recent trends with the suburbanization of formal settlement growth. On the other hand, the population size has increased in formal settlements by 14% between 2010 and 2020, despite a declining population density figure. The result indicated how large-scale condominium housing development, other low-cost housing, and real estate development are driving the formal settlement growth in Addis Ababa (Zewdie et al., 2021; Weldegebriel et al., 2021). The general picture showed that the growth rate of the population living in formal settlements has increased relative to deprived areas in recent years. Nonetheless, the higher annual informal settlement area growth rates than the formal settlement growth rates for the suburban sub-cities of Nifas Silk, Kolfe Keranyo, and Yeka indicated the new trends of suburbanization of informal settlement areas.

4.2.3.2. The identification of deprived areas based on slum ontological frameworks: Environment, settlement and object levels

Overview on conceptual model slum ontological levels.

The concept of slum ontology is the underpinning for the identification of informal settlements by analyzing deprived areas according to hierarchies of environment, settlement, and object level

(Kohli et al., 2012a). Additionally, observations, an earlier survey, a previous study of informal settlement, and ground verification fine-tuned the deductive levels of the slum ontological framework. The identified settlements were validated and classified through ground reconnaissance using 113 ground control points, filling out an attached questionnaire describing morphological characteristics, and our previous survey. In Ethiopia, informal buildings are housing that breaches building codes and regulations (Mahiteme 2014), which makes easier the delineation of substandard building areas based on the organic layout of settlements and roads, as well as the variable orientation of buildings. Therefore, in VHR, it is easier to delineate deprived areas where there are clusters of substandard buildings and road layouts.

Environment-level analysis of urban morphology based deprivations

At the environmental level, the location in relation to the riverbank and slope as well as the neighborhood characteristics in relation to overcrowded living conditions (high population and built-up density), crop area, grass and open space, and trees were analyzed against a deprived area using LRA based on longitudinal data. For 2010, the LRA indicated that the deprivation area was explained by the independent variables Pop_Dens ($p < 0.001$) and Rive_Pro ($p < 0.003$). The higher the proportion of settlements with a 50-meter river buffer (Rive_Pro), the higher the likelihood of an informal settlement, validating the location of an informal settlement along the banks of the river in Addis Ababa (Azagew & Werku 2020; African Development Bank Group and Municipal Development Fund, 2021; Bikis & Pandey 2022). Furthermore, in 2010, the likelihood of living in a deprived area increased twice for areas with a population density greater than 12000 people per square kilometer (Pop_Dens). The results supported the author's claim that a key morphological feature in 2010 for informal settlement detection was population or residential building density (Sori, 2012; Lemma et al., 2006; Sliuzas & Kuffer, 2008; Kuffer, 2017; Arif et al., 2022). From the current perspective, based on the LRA, the existence of deprived areas in 2022 was explained by environmental variables (Riv_Pro, Slop_Pro, and Crop_Pro). Accordingly, the deprived area is explained by the proportion of area with a slope $> 15\%$ (Slop_Pro), the crop area proportion from the settlement area (Crop_Pro), and the river 50-meter buffer area (Riv_Pro).

The preceding finding confirmed the location of an informal settlement in a crop area, riverbank, and sloppy area not suited for residential purposes (Oyinloye et al., 2018; Abebe et al., 2019; Azagew & Werku, 2020; African Development Bank Group and Municipal Development Fund,

2021; Bikis & Pandey, 2022). The population density (Pop_Dens) variable, however, does not predict informal settlement areas for 2022 in a manner like 2010. The temporal shift was due to the current population dynamics, which led to an increase in population density in suburban areas and the relocation of inner-city slum dwellers to suburban areas because of urban renewal interventions and the construction of large-scale condominium housing (Weldegebriel et al., 2021). The urban renewal, condominium housing, relocation from inner-city slum, and real estate development in the suburban area (Zewdie et al., 2021; Weldegebriel et al., 2021) may increase overcrowding in the suburb areas.

4.2.3.3. Settlement level identification

At settlement level, the shape of the settlement, buildings, roads, and green and open spaces based on texture and the pattern of density of buildings and green spaces were used for delineating informal from formal settlements. The morphologies of informal settlements are disaggregated into slums, regularized informal settlements, and peri-urban informal settlements. Regardless of typology, informal settlements generally depict the ontological properties of irregular road networks and layouts, small building sizes, and haphazard building orientation (Lemma et al., 2006; Sliuzas & Kuffer, 2008; Kuffer, 2017). In Addis Ababa, informal settlements proliferate along the banks of the river, in agriculture, on steep slopes, around religious institutions, and in forests (Azagew & Werku 2020; African Development Bank Group and Municipal Development Fund, 2021; Bikis & Pandey 2022). Nevertheless, high building density is a prominent feature in the inner-city slum areas of Addis Ababa, densified through additional construction or 'kitya houses' (Tarekegn, 2000).

A slum's typical features include small, old, dilapidated dwellings; an irregular local road; and a lack of greenery or open space (Lemma et al., 2006; UN-Habitat III, 2015; UN-Habitat, 2017). In addition, the slum's morphological properties include a lack of access to the right of way for some residents and the interspersed irregular local roads with renovated collector roads. The peri-urban informal settlement started in the late 1970s or early 1980s (Daniel, 2006; Erena, Berhe, Mammuru, and Soresa, 2017), and has increased since 1994 after regularization (Melese, 2005; Samson, 2010; Erena et al., 2017; Zewdie et al., 2021; Berhanu et al., 2022). Thus, the farmers' informal transactions of agricultural land are a defining characteristic of peri-urban informal settlements (Samson, 2010; Erena et al., 2017; Berhanu et al., 2022). In the peri-urban

informal settlement, the early genesis of haphazard buildings is consolidated, depicting the theoretical framework of informal settlement evolution from infancy to consolidation to saturation (Sori, 2012). The formal settlements morphological properties are an organic settlement layout, a regular road layout, and similar space between buildings (Lemma et al., 2006; Sliuzas & Kuffer, 2008; Kuffer, 2017). Currently, formal settlements shape the land use dynamics of suburban areas, especially with the construction of condominium housing and real estate development (Weldegebriel et al., 2021).

4.2.3.4. Object level identification

At the object level, the building's roof's shape, size, and color are analyzed and interpreted to detect the pattern of deprivation at the building level. Hence, the neighborhood information regarding the shape of the access road network and the characteristics of the building (built-up and non-built-up density) was analyzed and interpreted. The study interpreted the object's statistical information based on RF—the proportion and shape index of building density and natural features. By purposive sampling, two from each of the formal and informal settlements were selected, and analysis and interpretation were done at the object level.

In the Addis Ketema sub-city (an inner-city slum), deprivation was spotted as a huge chunk of the dark brown roof, representing the physical expression of old and rusted CIS. The dark roof extraction confirmed that the extraction of buildings or roof shapes faces challenges in densely packed urban areas of the slum where the roof is more irregular (Abascal et al., 2022). The dark brown roof is rusted CIS, and it is interspersed with smaller CIS, with roof colors ranging from silver to white, depicting maintained CIS replacing the deteriorated roofs. In the inner-city slum, the dark brown roof is the dominant roof, constituting a significant share of the roof, and depicting a more irregular shape relative to other roofs, deducing the old slum nature from the roof color. Thus, the dark brown roof, interconnected roof built-up, small-sized buildings, and high proportion of built-up depicted the deprivation in the inner-city slum, which was extracted based on object-based RF classification. The proportion of built-up land use is higher since the inner-city slum is densely packed. Yet, the green space was lower for the inner-city slum relative to other purposefully selected areas. The above result corroborated the fact that slums are characterized by high built-up density, less green space, and less ecosystem service supply (Lemma et al., 2006; Sliuzas & Kuffer, 2008; Sori, 2012; Kuffer, 2017; UN-Habitat, 2017; Arif

et al., 2022). The scenery of interconnected building roofs in the segmented image of the inner-city slum by itself reinforced the fact of "kitiya" houses in the inner-city slum (Tarekegn, 2000) and geared us to the deduction that informal settlement is a continuous process of change (Samper et al., 2020). Regular-shape red, light brown, medium brown, white, silver, and light blue building roofs represented most commercial buildings and some formal residential buildings in the northwest of Addis Ketema sub-city. The delineation of separate formal and informal buildings in the inner-city slum using an object-based approach (Leonita et al., 2018; Kuffer et al., 2020) revealed a refined estimation of formal and informal buildings in the inner-city slum areas rather than generalizing the smaller proportion of formal residential buildings into the slum.

In the peri-urban area, the dominant roof coverage is a white-colored roof, which appeared small in the quick bird's-eye view from the aerial photograph. The irregularity of the white roof is less pronounced compared to other buildings. The small-sized white roof in the peri-urban area is extracted with higher producer accuracy, implicating the easy detection of object shapes and pixels of white color in the actual class in relation to other classified objects in the peri-urban area. The white roof is an indicator of deprivation since it indicates a newly constructed house ("moon house") by informal settlers in one night, but the preparation takes time before erecting it (Heisel & Kifle, n.d.). The extraction of building roofs (except light and dark blue roofs) has lower user accuracy due to the similarity of shape and pixel reflectance with the natural features. The dark brown roof has very low user accuracy in peri-urban areas because pixels that represented tilled land were classified in the dark brown roof category, triggering an error of commission. The above fact reinforced the empirical evidence that spectrally similar objects degrade accurate building extraction (Huang et al., 2022).

In the peri-urban areas, crops were extracted with better user accuracy (less error of commission) since the classified objects had fewer classified objects having the same reflectance as the crops. Small building sizes in the peri-urban settlement are disproportional to a large vegetation fence or plot. The dwellers occupied a large plot to increase the capital of their own assets from the transaction of land rights if the tenure is regularized, while the building is small and substandard to reduce the cost of casualties if the building is liable to coercive bulldozing. Buildings constituted only 2.52% of the total area, indicating the infancy stage of settlement evolution (Sori, 2012), since most areas belong to homogeneous natural features.

The peri-urban lacked fundamental mixed land uses (Kamalipour, 2016; Arif et al., 2022); thus, it depicts a pattern of spontaneous residential settlement and a lack of infrastructure and services due to little or no statutory planning interventions. The land use is relatively diverse for the inner-city slum compared to the peri-urban area, despite the dense population and lack of basic infrastructure. So, compared to peri-urban informal settlements, land use in the inner-city slum is diversified, and the built-up area is drastically denser. Thus, relative to the newly constructed informal settlements, the land use is heterogeneous for older and more densely populated slum communities' (Arif et al., 2022). Like the inner-city slum building, the peri-urban building has an irregular roof; however, the building's irregular shape is considerably more pronounced in the inner-city slum due to the clump of interconnected old and deteriorated roofs.

The accuracy and Kappa coefficients for the formal impervious surfaces and natural features were higher in comparison to informal settlements. This is because object-based classification detects objects with high accuracy in regular and formal buildings, while it is more challenging in areas with irregular roofs in informal settlements. In sum, the object detection challenge was rooted in the complexity related to the textural, geometric, and spectral pattern (Mathenge, 2011; Thomas et al., 2003; Abascal et al., 2022; Huang et al., 2022); however, the empirical fact is that object-based classification has shown improvement relative to pixel-based classification (Thomas et al., 2003; Gram-Hansen et al., 2019) for deprived or substandard building detection. Silver-colored roofs were the dominant scene in the intermediate and expansion areas of formal settlement, in contrast to the irregular dark brown roofs in the inner-city slum areas. The road and space between buildings are more regular in formal settlement areas. User detection accuracy was poorer for the dark brown building roof in formal areas, which is partially a relic of the corroded CIS. This resulted from the old, dark brown roof's segments' irregular shape and texture, which degraded object detection in contrast to other features. The intermediate formal areas, the ones that are well integrated into mainstream urban development, have more regular green space, even exceeding the shape index of regular buildings in the area. The common feature governing the intermediate and expansion areas' formal settlement is the heterogeneous and balanced distribution of cultural and natural features, as well as planned and regular buildings and roads accessible to dwellers. In sum, informal settlements lack fundamental planning for mixed land uses, while formal settlements have more heterogeneous and accessible land uses (Kamalipour, 2016; Arif et al., 2022).

Chapter Five: Summary, Conclusions and Recommendations

5.1. Summary and Conclusions

5.1.1. Summary and Conclusion for specific objective 1

The research found that the deprivations of sustainable livelihood capital assets (financial, physical, human, and social) are interrelated. Therefore, solving the crucial strategic issues that relate to multifaceted problems will solve the related problems in phase-based ABS. Hence, the issues that relate to multifaceted deprivations of livelihood capital assets are validated with theoretical and empirical findings to refine pillar problems and their replicabilities in other contexts. The derived strategic issues also considered aspects of social exclusion or deprivation variations by sub-groups as well as institutional and capability aspects.

The research implicated the relevance of subsidies as the living costs for food, energy, and other expenditures are exorbitantly high due to the poor urban reliance on the cash economy. The study also illustrated the relevance of credit, as there are strong interrelationships between deprivations of financial capital assets and physical capital assets; therefore, providing credit for the housing improvement of the poor and using their property as collateral contributes to poverty alleviation. The vulnerability of the elderly to low incomes illustrates the relevance of social protection policies. The mainstreaming of gender and marital status for realizing equal employment and education, as well as the special intervention for providing employment for youth in secondary education, shall be given due policy consideration. The social policy interventions shall also consider mainstreaming interventions based on income, gender, tenure, unemployment, and educational status due to the study's indication of social exclusion by vulnerable groups. Parental education shall be given utmost focus, as low parental education has a trans generational effect on poor income and the low education status of children, which triggers the vicious circle of poverty. The low education levels of the poor also implicated public investment to enhance the skills of the poor and vulnerable groups to ensure the once-existing livelihood capital assets were not to be eroded in line with the asset theory of social preference. The overcrowded living condition is related to income poverty and unemployment and needs urban design interventions in the housing of the poor to ease overcrowding and achieve optimum density. Since tenure security is a strategic issue related to deprivations of

financial and physical capital assets, the implementation of incremental regularizations through a based approach that recognizes occupancy and group tenure rights to lease rights, backed by a robust land registration system, inhibits eviction, and discourages land speculators. The sound planning interventions and orchestration of existing regulatory frameworks shall support the realization of incremental regularization. The different forms of hazards (flood, landslide, toilet overflow, polluted river) affecting the community indicated the incorporation of urban resilience discourse and environmental protection with informal settlement interventions and poverty alleviation.

The study also found that a lack of institutional capital and bargaining power inhibited the access and control of tenure rights, services, and infrastructure by the poor and vulnerable groups. The existing local organizations of the poor shall be strengthened to advocate for the rights of the poor for services and infrastructure, as well as protect them from being evicted. The lack of institutions (especially in peri-urban areas) calls for diverse institutions to bring livelihood capital assets closer to poor people, backed by mainstreaming interventions by sub-groups. The study found that the synergy of multiple institutions (local, government, and non-government) plays a crucial role in realizing asset-based social policy through the pragmatic functioning of capability and enhancing the control and access of livelihood capital assets closer to poor people. The synergy of diverse institutions played a role in capability functioning by assisting the poor to live based on their livelihood aspirations and preferences, involving the poor in the work they can do with the resources, enhancing individual and collective capability, making livelihood capital assets closer to poor people, realizing meaningful asset accumulation and consolidation, and reducing risk and vulnerabilities. The future planning approach should follow negotiated planning, incorporating the interests, power, and aspirations of the poor and vulnerable groups for pragmatic asset-based social policy. The asset accumulation of the poor shall be further supported through the design of policies, legislation, and strategies that protect the erosion of existing assets, protect vulnerable groups, and encourage asset accumulation and consolidation through stages of asset accession, asset valorization, and asset transformation. Finally, the expenditure on social protection shall be increased in Ethiopia to reduce inequality since the expenditure is less than the average African standard, despite the research justifying large vulnerable groups in the population.

5.1.2. Summary and Conclusion for specific objective 2

Addis Ababa has highly accelerated population growth, largely owing to the high rates of net immigration from both rural and urban areas, which leads to urban inequality, a divided city, and an escalated housing crisis. If the current high urbanization trend and challenges continue, Ethiopia's level of urbanization will constitute more than one-third of the total population before 2035 with urbanization of poverty. Urbanization in Ethiopia does not correspond to economic development compounded by the challenges of urbanization. Thus, inclusive cities and sustainable urbanization can be realized through appropriate regularity instruments and area-based tools that tackle concentrated poverty, social exclusion, and spatial inequality.

In line with the research questions, the study substantiated the overlaps of a multitude of problems using indicators and components, developed MDI, and revealed the spatial pattern of inequality. The study also indicated the disproportional deprivation of large and vulnerable populations by analyzing deprivation versus population size and density. Then, the research suggested the justification for area-based policy based on the findings. The research triangulated the analysis of important indicators and components of PCA with a corresponding spatial pattern of components to enrich internal validity.

The overall spatial and statistical analysis indicated the multiple deprivations faced by the urban poor and the deepening of spatial and social inequality. MDI tools help to locate and prioritize the poorest of the poor in the endeavor to meet SDG 10 on inequality since MDI measures the multiple deprivations of sustainable livelihood capital assets suffered by the poor. By combining PCA indicators and factors with SDGs and conceptual frameworks, the MDI indicators and factors are aligned with the external context to keep track of SDG targets and offer future directions for achieving the SDG. Moran's I and LISA revealed the overall and local spatial pattern of components and enriched the findings of PCA, determining whether the stated problems overlapped in space to prove the spatial polarization of deprivations and ultimately create spatial inequality. The Morans' I-positive index, based on the coefficients of all components of the MDI in 2007 and 2016, is statistically significant enough to infer concentrated poverty and spatial inequality. The LISA spatial pattern indicated that a multitude of deprivations overlapped in informal settlements relative to formal settlements. The validation of PCA

indicators and components with the LISA pattern not only revealed spatial inequality but also the areas where deprivation occurred in relation to specific components and indicators. The result also implicated converging strategies and policies to reduce spatial inequality.

In generic form, poor education, income, vulnerability, congestion, non-durable housing, poor services and infrastructure, and poor green access are the critical indicators that overlap in space. The above overlapping indicators or problems indicate that the urban poor faced a multitude of problems between MDI 2007 and 2016. Based on the refined indicators and components, the most pervasive deprivation problems are deprivations of human capital, substandard housing materials, and poor services, as articulated in MDI 2007 component 1. The triangulation of indicators based on these study findings and the SDG confirmed that Addis Ababa's issues are in sync with globally agreed indicators. For instance, the most pervasive problems, based on MDI 2007 component 1, such as non-durable housing materials, poor sanitation services, and poor water services, conform to the housing inadequacy indicators of SDG 11. The MDI 2007 component 2 indicators of overcrowding and deprivation of own tenure rights (a high proportion of renters) conform to SDG 11 housing inadequacy indicators. In addition to the housing inadequacy indicators aligned with SDG 11, MDI 2007 component 2 reflected general problems of social and economic vulnerability, social exclusion, and poor living conditions. Thus, vulnerability indicators reflect deprivations.

Based on the assessment of MDI 2016 components 1 and 3, the urban regeneration interventions shall provide adequate open space, green space, and infrastructure access for social, economic, and health-vulnerable groups in slums and informal settlements to meet SDG 11 target 11.7. Furthermore, for the MDI 2016 components, the relationship between indicators of building density, green space, and vulnerable social groups implicates morphological features from satellite images as indicators of deprivation. Based on MDI 2016 component 2, low financial capital and low human capital assets (poor education and low-paying jobs) are reinforcing each other, which justifies the link between SDG 1 on poverty, SDG 4 on education, and SDG 8 on employment opportunity to alleviate the challenges of future urbanization.

Despite Addis Ababa's large number of deprived people in informal settlements, general deprivation trends show a downward trend. Deprivation, however, is polarized in slums and

suburban informal settlements that seek policy interventions to bridge inequality and the spillover effect of concentrated poverty. The inner-city consolidation, illegal building additions, and the repository of recent migrants worsened the concentration of deprivations. In addition, there is an exodus of rural-urban migrants who settled in peri-urban areas despite being faced with sporadic coercive bulldozing. The concentration of deprivation and population density in the inner-city slum, as well as the association of deprivation with less densely populated areas of the peri-urban zone, provided a conceptual model where the disadvantaged people were located and manifested a pattern of the divided city. The concentrated poverty means the relevance of MDI to prioritize area-based targeting of beneficiaries or people who needed social protection or strategic planning interventions in line with urban form.

In Ethiopia, the postponement of the planned census in 2018 due to social unrest limited the ability to compare the MDI using similar indicators and forecast future trends in deprivation. Nonetheless, deprivation has been studied recently by researchers by interpreting morphology from cost-effective high-resolution images and sometimes in combination with other socio-economic information. The MDI 2016 development, integrating the survey conducted by the CSA every 5 years with other information, is one option for preparing a cost-effective and time-efficient MDI and monitoring deprivations. The MDI is a composite tool that integrates data from various sources into usable information, including censuses, government surveys, base maps, remote sensing imagery, and so on.

5.1.3. Summary and Conclusion for specific objective 3

The informal settlement area proportion and annual growth trends have shown declining trends through the course of twelve-year periods (2010-2022), even though the absolute number of the population living in informal settlements might increase, fitting the SDG empirical frameworks. The informal settlement area proportion and annual growth trends have shown declining trends through the course of twelve-year periods (2010–2022), even though the absolute number of the population living in informal settlements might increase, fitting the SDG empirical frameworks. The informal settlement area decreased by a negligible percentage in the inner-city slum, while it showed sound growth trends in suburban areas. Yet, the population in the informal areas was nearly 2/3 of Addis Ababa's population in 2010, even though the deprived and less deprived

areas were equivalent. The population of informal settlements has shown a reasonable decrement of 14% between 2010 and 2020, which indicates Addis Ababa has shown sound improvement in meeting SDG 11 regarding the decrease of the population living in informal settlements or inadequate housing. In light of the 2010 and 2022 trends in deprived and less deprived areas, formal settlements have shown increasing trends surpassing informal settlement growth due to grand condominium housing projects, real estate development, and the relocation of the inner-city slum due to urban renewal. The preceding finding confirmed that, in addition to inner-city slums, densities are increasing in formal housing projects and condominium housing in suburban areas, reinforced by relocation and urban renewal in the inner city. In sum, currently, compact morphology is shaping the formal development pattern.

The slums' ontological frameworks are the basis for evaluating and interpreting poverty and deprivation since the informal settlements and slums are the tangible and long-lasting manifestations of deprivation, poverty concentration, and social exclusion. The slum ontology conceptual framework is tailored to the local context ontology by considering the ground verification of 113 sampled points, the regulatory framework from literature, and the study on Addis Ababa's inner-city slums and peri-urban areas. The research extracted temporal information from LR and VHR images using mixed methods: manual delineation of settlements, pixel-based ML, and object-based ML.

According to the research, it is possible to identify deprived areas and objects at the ontological levels of environment, settlement, and object, either by describing deprived areas or objects or by relating variables that explain deprivations. While predicting the results for 2010 and 2022, LRA related to and examined the magnitude of the effect of environmental variables on predicting the likelihood of a binary result—deprived area or not. In 2010, deprived areas were related to very dense living conditions and locations near riverbanks, but other factors had insignificant effects. In 2022, based on analysis at environmental levels, deprived areas were located in agricultural land, along riverbanks, and in hilly areas reserved for afforestation by statutory planning. Due to the failure of the land supply for housing, the poor are being forced to settle in non-residential areas that are less prone to forcible bulldozing, such as riverbanks, higher slopes, and crop areas (misidentified as farmer houses). Thus, pragmatic housing and regularization policies need to be implemented rather than rampant coercive bulldozing, taking benchmarks from countries that

curb informality. Regarding population density, in 2010, there was a twofold likelihood of being an informal area if the population was very dense, like the ontological framework identification of slums by high built-up and population density. Nonetheless, population density for 2020 did not predict the likelihood of a deprived area in 2022, as density is becoming a normative pattern in formal development areas.

At the settlement level, the ontological framework of slums is a useful tool for characterizing deprived areas. Yet, the local context definitions and ground verifications shall support the concept of slum ontology. In this study, observations, a prior survey of informal settlement areas, and ground verification validated and enriched the settlement-level identification of the concept of slum ontology. The lesson is that manual settlement delineation (relative to automatic) requires a lot more time, even though it gives the opportunity to detect small deviations for recognizing informal settlements adapted to local situation ontologies.

The most prevalent ontological characteristics of the informal settlement are the organic layouts, such as uneven road and building shapes and orientations, and small building sizes. There is a sound difference in ontological properties based on the typology of informal settlements (slums), regularized informal settlements, and peri-urban informal settlements. Slums are typically configured based on the morphological properties of high building density and a lack of green and open spaces. Thus, slums are the result of continuous illegal construction liable to the absence of ecosystem service supply. In addition, a lack of rights of way for dwellers and a location on a polluted river characterize the inner-city slums of Addis Ababa. Small building sizes, organic settlement layouts, and the critical absence of infrastructure characterize peri-urban informal settlements. Hence, spontaneously mushrooming buildings, unplanned open and green spaces, and a pattern of small buildings with big undeveloped plots (in their infancy stages) are features of peri-urban informal settlements.

The regularized informal settlement areas, mostly located in the intermediate locations, are areas where organic and inorganic layouts are mixed up and require building-level analysis with artificial intelligence to screen formal from informal buildings. The regularized informal settlement's social gentrification implicated a portion of the property holders who transacted their property rights for the affluent after regularization. The above pattern indicated that direct

regularizations do not provide meaningful results for decreasing the proportion of the population living in informal settlements as the regularized proprietors sell the property and retrace their previous steps of buying land again in the informal land transaction. Formal settlements have regular shapes and orientations of buildings and roads, as well as planned common areas—greenery and open spaces. Similar spaces between buildings also characterize formal settlements. The intermediate formal areas have more planned green spaces relative to the formal settlements situated in the expansion areas.

The ontology of the slum is identified for impermeable and permeable surfaces at the object level using ML algorithms. In the study, roof color, shape, and texture were extracted and analyzed using object-based RF classification. The RF neighborhood characteristics (building proportion, road shape and orientation, and reflectance and shape of natural features) were also analyzed for analysis and interpretation. Based on object-based RF, the image is trained by taking large samples for effective classification and verification on the ground reality based on confusion matrix. In accordance with the result, the formal and informal buildings, and the neighborhood information, four areas sampled from formal and informal settlement areas were identified. The overall Kappa's coefficient, which ranged from substantial to almost perfect, justified the rationale of using object-based classification relative to pixel-based classification for scrutinizing deprived objects (buildings) in relation to neighborhood information. The object-based classification, with an appropriate segmentation scale, can clearly identify formal buildings located in informal settlement areas. Thus, the object-based approach overrides the settlement-based approach for in-depth deprivation scrutiny and upgrading interventions by interpreting reflectance, textural, topological, and contextual information. Nevertheless, the irregularity and clumps of building roofs in the inner-city slum areas, reinforced by rampant illegal additions, make the extraction of individual roofs or buildings with meaningful geometric shapes difficult.

The tightly packed rooftops in slum neighborhoods, which are so close to the property line as to be practically invisible, are an indication of physical deprivation. Moreover, in the inner-city slum, the dominance of dark brown roofs, a relic of rusted CIS, authenticated the old and dilapidated nature of the inner-city slum. However, the dark brown roofs in peri-urban informal settlements showed lower user accuracy, validating the fact that spectrally similar objects present a challenge for plausible building extraction and configuration. The heterogeneity and diversity of uses in informal settlements lack fundamental mixed land uses compared to formal

settlements. Nonetheless, the heterogeneity of uses is absent in the peri-urban area and better in the inner-city slum, despite the critical lack of green and open spaces. In the peri-urban, the dominant roof is the small, white-colored roof, a deprived structure in the modern sense, the legacy of "moon houses" constructed with vernacular architecture. Object-based roof identification accuracy is degraded in peri-urban informal settlement areas overwhelmingly dominated by natural features. Therefore, in natural feature-dominated areas with no heterogeneity in land uses and no need for further disaggregation of roofs with detailed textural, contextual, and geometric information, pixel-based ML is the recommended approach. Formal building depicted inorganic layout, a mixed color of roof, heterogeneity of land uses.

5.2. Recommendations

5.2.1. Recommendations for Specific objective-1

The study recommends asset accession, asset valorization, and asset transformation for implementing ABS policy. The ABS policy is derived based on the strategic issues of the interrelationships of deprivations of sustainable livelihood capital assets, assessments of the capability and institutional aspects, and risk and safety assessments. The ABS policy recommendations are described in Table 21 below. The study also underscores that the quantitative interrelationship among deprivations of sustainable livelihood capital assets and their implications for policy and strategy are under-researched areas, despite the fact that the qualitative aspects of livelihood capital are studied; therefore, the quantitative aspects of deprivation interrelationships together with other components of livelihood capital assets and their relevance for policy and strategy on informal settlement interventions and poverty should be investigated in different locations and settings of informal settlements in the future.

Table 23 recommendation for Asset accession, Asset valorization and Asset transformation for attaining ABS policy, disaggregated by Livelihood Capital Assets (LCA).

LCA	Asset accession	Asset valorization	Asset transformation
Human capital	<ul style="list-style-type: none"> - Registering and targeting low education level HHs (with gender mainstreaming) for informal education provision. - - - Ensure food security/nutrition and participate in livelihood capital asset accumulation -Public works opportunities for the poor and vulnerable HHs Sub-groups. - Priority of MSSE employment opportunities for unemployed youths who failed secondary education. - Public awareness of transmittable diseases, especially for vulnerable HHs (overcrowded HHs and poor environment services). - Provide social protection for vulnerable HHs sub-groups (old and disabled) who cannot engage in productive work. -Assessment of the preferences and work the poor can do and be with the resources they have. 	<ul style="list-style-type: none"> - Investment in informal education for low education level HHs with gender, and marital status mainstreaming. - Investment in skilled training tailored to the functioning of capabilities of the poor and vulnerable HHs sub-groups. - Investment in technical vocational training through providing priorities for youths who failed secondary education - Investment and awareness training on transmittable diseases by providing priority for highly vulnerable sub-groups -Investment and tap resources in social protection by working in partnership with civic society, and multilateral and bilateral agencies for assisting vulnerable sub-groups (old and disabled) who cannot be engaged in productive work 	<ul style="list-style-type: none"> - Recognizing informal education in formal government and private work opportunities based on the work they are able to be and do. - Certification accrediting the capability of poor and vulnerable HHs sub-groups. - Policy and regulation design and make pragmatic to provide job opportunities priority for the poor and vulnerable HHs sub-groups in the work they are capable and do (the functioning of capability). - Policy and regulation design and implementation to provide priority job opportunities based on capabilities for youths who failed secondary education. - Commence regular mass media program for transmittable disease prevention and health resilience
Physical capital	<ul style="list-style-type: none"> - Recognize the various forms of rights for all tenure groups including group tenure and occupancy rights for landless in regulatory frameworks. - Authenticate and recognize the right to residence and on-site accommodation planning regulations (upgrading, land consolidation/ readjustment, land-sharing, and low- 	<ul style="list-style-type: none"> - Investment in the provision of various forms of tenure such as group tenure and occupancy right for landless - -Subsidize and invest in planning, design, services and infrastructure provision for informal settlements, especially in socially excluded and inaccessible areas. - Investment in the 	<ul style="list-style-type: none"> - Legitimize and gradually, through long term, transform the occupancy and group tenure right to lease right. - The informal settlement neighborhoods integrated with mainstream formal urban development. - Remove legal frameworks (building permit and regularization) that exclude physical capital asset accumulation for poor and

	<p>income housing) with strong negotiation with the poor in informal settlements.</p> <ul style="list-style-type: none"> - resilience discourse-oriented policy and planning and housing design measures to ease high overcrowding and communicable disease transmissions 	<p>implementation of planning and housing design to ease overcrowding.</p>	<p>vulnerable HHs sub-groups.</p> <ul style="list-style-type: none"> - Housing policy implementation ensures on-site accommodation. and vertical development (less overcrowding or optimal density). -Ownership right recognition regulation inhibits relocation and eviction of the poor and the land right dispossessed HHs.
Financial capital	<ul style="list-style-type: none"> - Subsidizing the living cost of the poor (food, water, sanitation, health, transport, and education) and vulnerable sub-groups incorporated in multilateral and bilateral agencies programs through cash transfer and subsidies. - Local administrative offices avail foodstuff at a subsidized cost for the poor HHs and vulnerable sub-groups. - School feeding for poor students. - Introducing energy-saving and cost-effective cooking technologies. - Recognize the role of social inclusion (formal + informal) in matching fund contributions. - Facilitate financial institutions that provide a low-interest rate for poor and vulnerable subgroups of MSSE involvement. - Design methods and incorporate benchmarks for diversifying income sources for the poor. 	<ul style="list-style-type: none"> - Investment in training regarding saving, entrepreneurship, and diversifying income sources for beneficiaries HHS in partnership with government, multilateral and bilateral agencies. - Private organizations provide asset-based lending for machinery and equipment with subsidized cost for the poor. - Opening blocked saving bank accounts for beneficiaries' HHs that guarantee credit opportunities. - Investment in producing energy-saving and cost-effective cooking materials and distributing them to the poor and vulnerable sub-groups at low cost. - All dwellers contributed matching funds (formal + Informal) - Provide low-interest-rate priority for chronically poor and vulnerable sub-groups for MSSE development and UPSNP capability functioning. 	<ul style="list-style-type: none"> - The saving groups obtained credit opportunities to engage in job opportunities or aspirations they want to be and are capable of doing. - Opportunities for asset-based lending for the poor and vulnerable sub-groups based on legitimized right as collateral for credit. - Scale-up energy-saving and cost-effective cooking technologies to other informal settlements. - Legal framework recognized the contribution of matching funds by all dwellers. - Chronically poor dwellers established profitable MSSE. - Diversifying income sources enhance capital consolidation

Social and institutional capital	<p>-Formulate, increase, and recognize the legitimacy of CBO and civic societies in local organization structure as partners of livelihood capital asset accumulation.</p> <ul style="list-style-type: none"> - Government recognizes and supports programs and projects of multilateral and bilateral agencies working in poverty alleviation and asset building. - The government and the dwellers recognize and strengthen the existing structure of community police. 	<ul style="list-style-type: none"> - Investment in training and membership of CBO and Civic societies that worked for the interest of the poor and vulnerable sub-groups. - - - Decentralize the institution of community police at the community level and invest in human capital deployment and training. 	<p>Redesign Urban development policy and strategies to accredit and legitimize institutions bargaining for the needs of chronically poor, voiceless, and dispossessed land rights HHs.</p> <ul style="list-style-type: none"> - Strong multi-stakeholders' partnership of CBO, Civic societies, and multilateral and bilateral agencies. - Design social protection policy integrated with employment, poverty, and environmental policy. - CBO and civic societies bargain for rights in tenure, provision of services and infrastructure, inhibiting evictions for the voiceless poor, and dispossessed land rights HHs. - Making pragmatic safety and security regulations to reduce crime.
Natural Capital	<p>-Recognize the role of UPSNP, multilateral/ bilateral agencies, and civic societies in the protection of natural capital erosion.</p>	<p>Investment in providing awareness training regarding environment protection and management.</p> <ul style="list-style-type: none"> - Integrate the poverty alleviation programs investment with natural capital asset accumulations. 	<p>Building an environmentally resilient city that can respond effectively in case of shock and stress.</p> <ul style="list-style-type: none"> - Reduce the effect of environmental disasters on other livelihood capital assets.

5.2.2. Recommendations for Specific objective-2

The MDI, a composite index used in the study, is a tool for resource allocation, compensatory policy for disadvantaged areas, and urban upgrading or redevelopment interventions. The rationale for the area-based policy is evident in this study due to the overlaps and coexistence of problems revealed based on the high correlation of deprivation indicators. Furthermore, area-based targeting is rational due to the large and disproportionately deprived population

concentrated in slums and peri-urban informal settlements, the nature of the divided city, the challenges faced by the urbanization of Ethiopia, and the polarization of poverty and inequality.

The justification for area-based policy based on deprivation assessment shall be studied in different urban areas of the country for deriving countrywide area-based policy direction. The interrelated problems of livelihood capital asset deprivation in space imply that urban regeneration interventions must be supported by consistent sustainable livelihood capital asset accumulation for the deprived in order to address most of the SDG's targets in an integrated manner.

Addis Ababa's and other cities' practices revealed that capital budgets are disbursed without the use of any reliable tools, primarily taking the project's unit cost, population, and level of development into consideration. The world bank's lesson on several programs and projects showed that sector-based programs benefit the wealthy. Therefore, the local governments shall use the MDI tool for area-based targeting of poor beneficiaries, prioritizing the poor for social security benefits, urban upgrading, working in partnership with the local community, tax exemption and imposition based on neighborhood deprivation characteristics, and prioritizing the deprived population for phase-based interventions.

The challenges for the future urbanization of Ethiopia are poverty, unemployment, informal settlement problems, and a divided city. Yet, past research in Ethiopia has neither developed MDI tools nor identified the most important factors of area-based deprivation for solving problems of poverty, deprivation, and urban planning. This study provides methodological frameworks for area-based compensatory policy and extracting the crucial problems and indicators of multiple deprivations, as well as monitoring most of the SDG indicators in an integrated manner.

The spatial inequality and spatial polarization of deprivations using LISA indicate that problems overlap and coexist in informal settlements, which helps future strategic planners determine where to direct resources for compensatory policy, urban regeneration, and reducing spatial inequality and poverty alleviation. The same research can be conducted in other urban areas of Ethiopia to address multiple deprivations and monitor SDG progress in a country and the multitude of problems creating challenges for future urbanization. Based on MVAT analysis, low

education is the most robust indicator associated with slums and informal settlement areas other than the indicators forming the operational definition of the slum. For both the MDI 2007 and 2016, low educational attainment and the concentration of vulnerable groups are strong indicators of deprivation in inner-city slum areas.

A repeated study of MVAT analysis of multiple deprivations in other locations and urban contexts contributes to the development of indicators for the SDG if certain problems or indicators are repeatedly occurring in different countries. Based on MVAT analysis, tenure security is a strategic intervention because insecure residents are vulnerable to social exclusion, eviction, and the loss of physical capital asset accumulation. A key strategic intervention is to incrementally upgrade tenure from kebele renter status or no tenure rights to de jure tenure rights, backed with livelihood capital asset accumulation and consolidation.

The MVAT also indicates that SDG 1 indicators of poverty, SDG 4 on education, and SDG 8 on employment are interrelated and reinforce each other. The SDG's targets should be achieved in tandem to address multiple deprivation issues while also reducing the transgenerational impact of poverty traps by addressing the vicious circle of poverty. Because the financial and non-financial aspects are mutually reinforcing, as revealed by the effect of low income on low socioeconomic status, MDI development must consider both financial and non-financial components.

Deprivations versus population size and density showed how deprivation scores vary with the urban form to trigger a divided city pattern. The finding reinforced the rationale of area-based policy to reach large populations that are disproportionately deprived. Moreover, the concentrated poverty pattern implies that there is a likelihood of a negative neighborhood effect in concentrated poverty quarters or neighborhoods transmitted through a lack of role models and other mechanisms. Thus, quantitative neighborhood effect models and qualitative ethnographic research shall be conducted in concentrated poverty areas to study the transgenerational effect of concentrated poverty on individual and household poverty traps as well as the mechanism of transmission of the neighborhood effect.

5.2.3. Recommendations for specific objective-3

The current study reveals that small and medium-sized cities nearby Addis Ababa and cities located along important transport hubs have demonstrated stronger urbanization rates than Addis Ababa and the areas are future trajectories for the proliferation of informal settlements. Thus, deprivation and urbanization of poverty research shall focus on these areas.

Population density and built-up density had been the main driving forces explaining deprived areas or informal settlements in Addis Ababa in 2010 and recent past trends, Nonetheless, in 2020, density will become the driving force shaping not only the informal but also the formal morphology structure with the expansion of grand condominium housing projects. The above findings further implicate that the once-sprawled formal settlement trends have changed considerably to compact formal development, which needs further research on the driving forces behind the city's urban morphology change, density, and diversity of land uses.

Future studies should compare automatic extractions utilizing object-based machine learning versus deep learning techniques. Future research suggests focusing on comparing deep learning with manual digitizing. The advantages and disadvantages of the dominant choice approaches for the identification and categorization of deprived areas, slums, and substandard housing should also be stated in future research. Future policy interventions and research should concentrate on the relationships between informal settlements and local environmental features, such as riverfront locations, topographically restricted places, and agricultural holdings.

This research also provides the local context, methodological approaches, and framework for identifying the character, growth, and trends of informal and formal settlements as well as analyzing the formal and informal population so that urban areas can identify the extent, growth trends, population size, and character of informal settlements to monitor the status of SDG achievement by urban centers in Ethiopia.

The research indicated that substandard or deprived buildings can be identified based on roof color, shape, texture, and orientation, coupled with built-up proportion, and road shape, and complemented with a building shape index computation. Accordingly, this approach supplements a locally based statutory neighborhood planning implementation for upgrading and

redevelopment interventions by identifying standard and substandard buildings and computing the costs accordingly. The research also indicated and quantified the location and extent of deprived areas as basis for city wide upgrading interventions. The above methodologies were justified since SDG focuses on urban upgrading to decrease the proportion of the population living in informal settlements. Future research shall focus on relating the deprived area or object extracted from a high-resolution image with a sample survey or census of corresponding years to justify the sound generalization of poverty and deprivations from space.

References

- AACPPO[Addis Ababa City Planning Project Office]. (2017). Addis Ababa City Structure Plan 2017–2027. Addis Ababa City Administration:
https://c40-production.images.s3.amazonaws.com/other_uploads/images/2036_Addis_Ababa_Structural_Plan_2017_to_2027.original.pdf?1544193458 (accessed on 5 May 2019).
- Abagissa, J. (2019). Informal settlements in Addis Ababa: Extent, challenges, and measurements. *J. Public Adm. Financ. Law*, 15, 7–30 .
- Abascal, A., Rodriguez-Carreno, I., Vanhuyse, S., Georganos, S., Sliuzas, R., Wolff, E., & Kuffer, M. (2022). Identifying the degree of Deprivations from Space using deep learning and Morphological spatial analysis of deprived urban areas. Retrieved from <https://doi.org/10.1016/j.compenvurbsys.2022.101820>.
- Abebe, F. K. (2011). Modelling Informal Settlement Growth in Dar es selaam, Tanzania. In D. S. Negera, *Identifying and Classifying Slum Development Stages from Spatial Data* (pp. 575-593). Enschede: University of Twente, Faculty of Geoinformation and Earth Observation.
- Abebe, M. S., Derebew, K. T., & Gemedo, D. O. (2019). Exploiting temporal-spatial pattern of informal settlements using GIS and Remote Sensing Technique: a case study of Jimma city, Southwestern Ethiopia. *Environmental System Research* 8(6). Retrieved from <https://doi.org/10.1186/s40068-019-0133-5>.
- Abiy, M. (2020). Urban Productive Safety Net Program Contribution to Beneficiary Household (S) Food Security: A Case of Woreda Seven, Kirkos Sub City. Addis Ababa: Addis Ababa University.
- Abram, C. (1971). *Man's Struggle for Shelter in an Urbanizing World*. Cambridge: MIT Press.
- Aboderin, I., Kano, M., & Owil, H. A. (2017). Towards “Age-friendly” Slums? Health Challenges of Older Slum Dwellers in Nairobi and the Applicability of the Age-friendly City Approach. *International Journal of Environmental Research and Public Health*, 14(1259), 1–13. <https://doi.org/10.3390/ijerph14101259>.
- Addis Ababa City Government. (2011, October 24). Wikipedia-Addis Ketema. Retrieved 2017, from https://en.wikipedia.org/wiki/Addis_Ketema.
- Addis Ababa City Government. (2012). Tenure Administration Service Provision. Directive No.12/2004 E.C. Addis Ababa, Addis Ababa, Ethiopia: City Government of Addis Ababa, 09/16/2004 E.C.
- African Development Bank Group and Urban and Municipal Development Fund. (2021). Addis Ababa "beautifying sheger" River Development Project: Investment strategy and Infrastructure plan. African Development Bank Group.
- Agarwal, P. (2005). Ontological considerations in GIScience. *International Journal of geographic Information Science* 19 (5), 501-536.
- Ajami, A., Kuffer, M., Persello, C., & Pfeffer, K. (2019). Identifying a Slums' Degree of Deprivation from VHR Images Using Convolutional Neural Networks. *Remote Sensing*, 11(11), 1282. MDPI AG. Retrieved from <http://dx.doi.org/10.3390/rs11111282>.
- Alam, M. S. (1989). Spatial Dimensions of Development in Bangladesh. In P. R. Masud, *Mapping Urban Poverty and Deprivations: the case of Rajshahi City* [Doctoral dissertation, Hindu University]. Varanasi, India: Hindu University.
- Ambaye, D.W. (2015). Land Rights in Ethiopia. In: *Land Rights and Expropriation in Ethiopia*. Springer Theses. Springer, Cham. https://doi.org/10.1007/978-3-319-14639-3_2.
- Amphune, E. B., Weldegebiel, Z. B., & Enaro, Y. D. (2018). Migration and Urban Livelihoods: A Quest for Sustainability in Southern Ethiopia. *Global Journal of Human Social Science*, 25-39
- Analyttica Datalab. (2021, November 13). Understanding- 'Wald test'. Retrieved from <http://medium.com/@analyttica/understanding-wald-test>.
- Andrea, R.N. (2012). The importance of indices of multiple deprivations for spatial planning and community regenerations: The example of Welsh index of multiple deprivations and the related communities' first program for the Italian system. *Ital. J. Plan. Pract.* 2(2), 34–65. Available online: <http://www.ijpp.it/index.php/it> (accessed on 22 April 2019).
- Ansari, R. M., Rahim, K., Bhoje, R., & Bhosale, S. (2022). A study on Research Design and its types. *International Research Journal of Engineering and Technology* Volume 09(07).
- Anselin, L. (1995). Local indicator of spatial association-LISA. *Geogr. Anal.*, 27, 93–84.
- Arif, M. M., Ahsan, M., Devisch, O., & Schoonjans, Y. (2022). Integrated Approach to Explore Multidimensional Urban Morphology of Informal Settlements: The Case Studies of Lahore, Pakistan. *Sustainability*, 14(13), 7788. MDPI AG. Retrieved from <http://dx.doi.org/10.3390/su14137788>.
- Arroyo, L. (2013). Organized self-help housing as an enabling shelter & development strategy: Lessons from current practice, institutional approaches, and projects in developing countries. Lund, Sweden: Lund University.
- Assarkhaniki, Z., Sabri, S., & Rajabifard, A. (2021). Using Open data to detect the structure and pattern of informal settlements: an outset to support inclusive SDG's achievement. *Big Earth Data* 5(4). Retrieved from <https://doi.org/10.1080/20964471.2021.1948178>.

- Azagew, S., & Worku, H. (2020). Accessibility of urban green infrastructure in Addis Ababa city, Ethiopia: Current status and future challenges. *Environ Sys Res* 9(26). Retrieved from <https://doi.org/10.1186/s40068-020-00187-0>.
- Ball, J., Bewick, V., & Cheek, L. (2005). Statistics review 14: Logistic regression. *Crit Care*, 112-118. doi 10.1186/cc3045. Epub 2005 Jan 13. PMID: 15693993; PMCID: PMC1065119.
- Betelehem, T., Demiye, T., Eyob, M., Rahwa, M., Tigist, T., & Yishak, T. (2006). *Kolfe Area*. UK: University of Bath.
- Bhandari., P. (2020, November 30). External validity, Definition, Types, Threats, and Examples. Retrieved from Scribbr: <https://www.scribbr.com/methodology/external-validity/>.
- Bhandari, P. (2021, April 19). What Is a Controlled Experiment? | Definitions & Examples. Retrieved from Scribbr: <https://www.scribbr.com/methodology/controlled-experiment/>.
- Bhardwaj, G. S., & Kumar, A. (2019). The comparison of shape indices and perimeter interface of selected protected areas especially with reference to Sariska Tiger Reserve, India. *Global Ecology and Conservation* 17(1). Retrieved from <https://doi.org/10.1016/j.gecco.2018.e00504>.
- Baker, Judy; Schuler, Nina. (2004). *Analyzing Urban Poverty: A Summary of Methods and Approaches*. Policy Research Working Paper; No.3399: ©World Bank, Washington, D.C. <http://hdl.handle.net/10986/14244> License: CC BY 3.0 IGO.”
- Baker, J., & Claeson, C.-F. (1990). *Small Towns Africa: Studies in Rural-Urban Interaction*. Seminar Proceedings No.23 (pp. 1-258). Udevalla: The Scandinavian Institute of African Studies, UPPSALA.
- Baud, I., Pfeffer, K., Sridharan, N., & Nainan, N. (2009). Matching Knowledge to Urban Governance: Mapping Deprivations in three Indian Mega Cities. *Habitat International* 33 (4), 365-377.
Retrieved from <http://dx.doi.org/10.1016/j.habitatint.2008.10.024>.
- Baud, I.; Kuffer, M.; Sliuzas, R.; Sadasivam, K. (2010). Understanding Heterogeneity in Metropolitan India: The added value of Remote Sensing data for analyzing sub-standard residential areas. *Int. J. Appl. Earth Obs. Geoinf*, 12, 359–374.
- Beaumont, R. (2012). Retrieved from *An Introduction to Principal Component and Factor Analysis: Using SPSS 19 and R (Psych Package)*. 23 April 2012. Available online: <http://assessment-matters.weebly.com/blogs/an-introduction-to-principal-component-analysis-factor-analysis-using-spss-19-and-r-psych-package> (accessed on 7 June 2020).
- Bebbington, A. (n.d.). *Capitals and Capabilities: A Framework for analyzing peasant viability, rural Livelihoods, and Poverty in the Andes*. London: International Institute for Environment and Development.
- Bernard, H.R. (2011). *Research Method in Anthropology*. Available online: https://research-methodology.net/research-methodology/research-approach/inductive-approach-2/#_ftn2 (accessed on 12 December 2019).
- Berhanu, G.; Woldemikael, S.; Beyene, E.G. (2022). The interrelationships of sustainable livelihood capital assets deprivations and asset-based social policy interventions: The case of Addis Ababa informal settlement areas, Ethiopia. *Res. Glob.* 2022, 4(1), 100081. <https://doi.org/10.1016/j.resglo.2022.100081>.
- Berthoud, R. (1983). *Who Suffers Social Disadvantage?* In Brown, M., (Ed.), *the Structure of Disadvantage, SSRC/DHSS Studies in Deprivation and Disadvantage*. London, UK: Heinemann Educational Books.
- Bigman, D.; Fofack, H. (2019). *Geographic Targeting for Poverty Alleviation*. *World Bank Economic Review* 2000. Volume 14. Available online: <https://doi.org/10.1596/0-8213-4625-3> (accessed on 15 January 2019).
- Bikis, A., & Pandey, D. (2022). *Squatter Settlement and Informal Urbanization: causes and consequences*. *Environ Sci Pollut Res*. Retrieved from <https://doi.org/10.1007/s11356-022-23778-z>.
- Bondarenko, M., Kerr, D., Sorichetta, A., & Tatem, A. J. (2020). *Census/projection-disaggregated gridded population datasets for 51 countries across sub-Saharan Africa in 2020 using building footprints*. Retrieved from doi:10.5258/SOTON/WP00682.
- Botsi, P. (2017). *Multicollinearity: diagnostics and PCA as a method of handling* [Master's Thesis]. Thessaly, Greece: University of Thessaly School of Medicine Research Methodology in Biomedicine, Biostatistics and Clinical Bioinformatics.
- Breiman, L. (2001). *Random Forest*. *Machine Learning* 45, 5-32. Retrieved from <https://doi.org/10.1023/A:1010933404324>.
- Bundervoet, T. (2018). *Internal Migration in Ethiopia Evidence from a Quantitative and Qualitative Research Study*. Washington, DC, USA: World Bank. Available online: <https://openknowledge.worldbank.org/handle/10986/32097> (accessed on 12 September 2021).
- Calvello, M. (2020, March 23). *Come to the right conclusion with Inferential analysis*. Retrieved from <https://learn.g2.com/inferentialanalysis#:~:text=Another%20inferential%20analysis%20test%20is,are%20dependent%20on%20one%20another>.
- Cecilia, W. (2006). *Indicators for Urban and Regional Planning: The Interplay of Policy and Methods*. London: Routledge.

- Chao-Ying Joanne Peng, Kuk Lida Lee & Gary M. Ingersoll (2002) An Introduction to Logistic Regression Analysis and Reporting, *The Journal of Educational Research*, 96:1, 3-14, DOI: 10.1080/00220670209598786.
- Charles, K. W., & Thevenow-Harrison, in, J. T. (2014). Descriptive and Inferential problems of Induction: toward a common framework. In B. H. Ross, *Psychology of learning and motivation* (pp. 1-39). Illinois: Elsevier. Retrieved from <https://doi.org/10.1016/B978-0-12-800283-4.00001-0>.
- Chen, Y. (2022). *Reconstructing and Normalization of Anselin's Local Indicator of Spatial Association (LISA)*. Beijing, China: Department of Geography, College of Urban and Environmental Science, Peking University.
- Chojnicki, Z.; Czyz, T. (1976). Some problems in the application of factorial analysis in geography. *Geogr. Anal*, 3, 417–427. <https://doi.org/10.1111/j.1538-4632.1976.tb00548.x>.
- CMI. (2020, 04 11). Amartya Sen's capability theory approach. Retrieved from <https://www.cmiuniversal.com/en/amartya-sens-capability-theory-approach>
- Crotty, M. (1998). The foundation of Social Research: Meaning and Perspectives in the Research Process. In G. E. David, *Doing Research in the Real World: Theoretical Perspectives and Research Methodologies*. London: Sage.
- CSA (Central Statistical Agency of Ethiopia). (2007). *Addis Ababa Statistical Abstract*. Addis Ababa, Ethiopia: CSA.
- CSA. (2013a). *Population Projection of Ethiopia for All Regions at the Woreda Level from 2014–2017*. Addis Ababa, Ethiopia: CSA.
- CSA. (2013b). *Population projection for Ethiopia 2007-2037*. Addis Ababa: Central Statistics Agency.
- CSA. (2015). *Urban Unemployment Survey*. Addis Ababa, Ethiopia: CSA.
- CSA. (2021). *Ethiopian 2021 Labor Force and Migration Survey Key Findings*. Addis Ababa, Ethiopia: CSA.
- Carloni, A. S., & Crowley, E. (2005). *Rapid guide for missions Analysing local institutions and livelihoods Guidelines*. Rome: Food and Agriculture Organization of The United Nations.
- Caroline, O., & Moser, N. (2006). *Asset Based Approaches to Poverty Reduction in a Globalized Context: An Introduction to asset accumulation policy and Summary of Workshop Findings*. *Global Economy and Development Working Paper*, pp. 1-39.
- Chou, Y.H. (1995). Spatial pattern and spatial autocorrelation. In: Frank, A.U., Kuhn, W. (eds) *Spatial Information Theory A Theoretical Basis for GIS*. COSIT 1995. *Lecture Notes in Computer Science*, vol 988. Springer, Berlin, Heidelberg. https://doi.org/10.1007/3-540-60392-1_24
- Turner, J. C. (1982). The issue on Self Help and Self Managed Housing. From *Ward P.M Self Help Housing, a Critic*, Mansell, 99-113.
- Clelland, D.; Hill, C. (2019). Deprivation, policy, and rurality: The limitations and applications of area-based deprivation indices in Scotland. *Local Econ. Policy Unit*, 34, 33–50. <https://doi.org/10.1177/0269094219827893>.
- Conning, A., & Hall, B. (1992). Integrating demographic and socio-economic data with PC-based GIS in Latin America. *GISDECO Seminar*, (pp. 87-102). Utrecht.
- Coombes, M.; Raybould, S. (1989). Developing a Local Enterprise Activity Potential (LEAP) index, *Built Environment* 14. In *Indicators for Urban and Regional Planning: The Interplay of Policy and Methods*. Cecilia, W., Ed. Oxfordshire, UK: Routledge, 107–117.
- Crane, R.; Manville, M. (2008). *People or Place? Revisiting the Who Versus the Where of Urban Development*. Cambridge, MA, USA: Lincoln Institute of Land Policy.
- Creswell, J. W. (2003). *Research Design: Quantitative, Qualitative, and Mixed Methods Approaches*. Nebraska: International Educational and Professional Publisher.
- Creswell, J. W. (2009). *Research Design: Quantitative, Qualitative and Mixed Method Approaches*. London: SAGE.
- Crotty, M. (1998). The foundation of Social Research: Meaning and Perspectives in the Research Process. In G. E. David, *Doing Research in the Real World: Theoretical Perspectives and Research Methodologies*. London: Sage.
- Damas, P., & Israt, R. (2004). *Vulnerability and Poverty: What are the causes and How they are related?* Bonn: International Doctoral Studies Program at ZEF. https://www.zef.de/fileadmin/downloads/forum/docprog/Termpapers/2004_3a_Philip_Rayan.pdf
- Daniel, L. (2006). *An Assessment of the Development and Implementation of Regulations on Informal Settlement: the case of Addis Ababa City*[Master's thesis, Addis Ababa University]. Addis Ababa: Addis Ababa University.
- Dani, A. A., & Moser, C. (2008). Asset-Based Social Policy and Public Action in a Polycentric World. In C. Moser, & A. A. Dani (Eds.), *Assets, Livelihoods and Social Policy* (pp. 3–41). Washington, DC: New Frontiers of Social Policy, The World Bank.
- David, M., Helen, B., Joanna, D., Elisabeth, G., & Chris, D. (2011). *The English Indices of Deprivation 2010*. Retrieved Jan 1, 2017, from <http://www.poverty.ac.uk/definitions-poverty/deprivation-and-poverty>
- Deas, I.; Robson, B.; Wong, C.; Bradford, M. (2003). Measuring neighborhood deprivation: A critique of the index of multiple deprivations. *Environ. Plan. C Gov. Policy*, 21(6), 883–903. <https://doi.org/10.1068/c0240>.

- Deichmann, U. (1999). Geographic Aspects of Inequality and Poverty. Retrieved from https://web.worldbank.org/archive/website01407/WEB/IMAGES/5319_POV.PDF
- Debebe, S.; Zekarias, E.H. (2020). Analysis of poverty, income inequality and their effects on food security in southern Ethiopia. *Agric. Food Secur.*, 9(16). <https://doi.org/10.1186/s40066-020-00269-3>.
- Desheng Liu & Fan Xia (2010) Assessing object-based classification: advantages and limitations, *Remote Sensing Letters*, 1:4, 187-194, DOI: 10.1080/01431161003743173.
- De Soto, H. (1989). *The Other Path: the invisible revolution in Third World*. London: I B Taurus.
- De Soto, H. (2001). *The Mystery of Capital*. In F. Edesio (Ed.), *The Influence of De Soto's The Mystery of Capital*. London: Bantam Press.
- De Risi, R., De Paolola, F., Jalayer, F., & Lervolina, L. (2013). Flood Risk assessment for Informal Settlements. *Natural Hazards* 69(1). DOI: 10.1007/s11069-013-0749-0.
- Ding, W., Jimoh, S. O., Hou, Y., Hou, X., & Zhang, W. (2018). Influence of Livelihood Capitals on Livelihood Strategies of Herdsmen in Inner Mongolia, China. *Sustainability*, 10, 3325. <https://doi.org/10.3390/su10093325>.
- Donna, M. M. (2009). *Transformative Research and Evaluation*. New York and London: The Guilford Press.
- Doreshor, K., Dereje, S., Henok, K., & Mohammed, H. (2016). Scenario of Urban Poor: Case Study of Addis Ketema(Woreda-07) in Addis Ababa City. *International Journal of Social Science and Humanities Research*, Vol.4, Issue 2, 36-41.
- Drakakis-Smith, D. (1981). *Urbanisation and the Development Process*. London, UK, 1981: Croom Helm. <https://doi.org/10.4324/9780203836828>.
- Elias, A.Y. (2008). *Revisiting Slums, Revealing Responses: Urban Upgrading in Tenant Dominated Inner-City Settlements, in Addis Ababa, Ethiopia* [Doctoral Dissertation, Norwegian University of Science and Technology]. Trondheim, Norway: Norwegian University of Science and Technology.
- ECE (Economic Commission for Europe). (2008). *In Search of Sustainable Solutions for Informal Settlements in the ECE Region: Challenge and policy Response*. Geneva: Unedited Draft, Sixty-ninth Session.
- Eckestein, S. (1990). Urbanization revisited:inner city slum of hope and squatter Settlement of despair. *World Development* Vol.18. No.2, 165-181.
- Endris, E., & Kassegn, A. (2022). The role of micro, small and medium enterprises(MSMEs) to the sustainable development of sub-Saharan Africa and its challenges: a systematic view of evidence from Ethiopia. *Innov Entrep* 11 (20). Retrieved from <https://doi.org/10.1186/s13731-022-00221-8>.
- Erena, D. B., Berhe, A. G., Mammaru, T. L., & Soresa, Y. A. (2017). *City Profile Addis Ababa*. Report prepared in the SES (Social Inclusion and Energy Management for Informal Urban Settlement). Retrieved from <http://moodle.donau-uni.ac.at/ses/>.
- ESRI (Environmental System Research Institute). (2017, November 27). *Machine Learning in Arcgis*. Retrieved from [https://www.esri.com/arcgis-blog/products/analytics/analytics/machine-learning-in-arcgis/#:~:text=Machine%20Learning%20\(ML\)%20refers%20to,classification%2C%20and%20clustering%20of%20data](https://www.esri.com/arcgis-blog/products/analytics/analytics/machine-learning-in-arcgis/#:~:text=Machine%20Learning%20(ML)%20refers%20to,classification%2C%20and%20clustering%20of%20data).
- ESRI. (2022a). *How Spatial Autocorrelation (Global Moran's I) works—ArcGIS Pro Documentation*. 7 September 2022. Available online: <https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/h-how-spatial-autocorrelation-moran-s-i-spatial-st.htm> (accessed on 19 October 2022).
- ESRI. (2022b, October 28). *Sentinel-2 10m land cover time series of the world*. Retrieved from Living Atlas: <https://www.arcgis.com/home/item.html?id=cfb7609de5f478eb7666240902d4d3d>.
- ESRI. (2023, February 1). *ArcGIS Pro*. Retrieved from *Train Random Trees Classifier (Spatial Analyst)*: <https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/train-random-trees-classifier.htm>.
- Ethiopian National Planning Commission (ENPC). (2017). *Ethiopia's Progress Towards Eradicating Poverty: An Interim Report on 2015/16 Poverty Analysis Study*. Addis Ababa, Ethiopia: National Planning Commission.
- European Space Agency. (2021). *Copernicus Global Digital Elevation Model*. Distributed by OpenTopography. <https://doi.org/10.5069/G9028PQB>. Accessed: 2023-02-25.
- Fabrigar, L.R.; Wegener, D.T.; Macallum, R.C.; Strahan, E.J. (1999). Evaluating the use of exploratory factorial analysis in psychological research. *Psychol. Methods*, 4, 272–299. <https://doi.org/10.1037/1082-989X.4.3.272>.
- Fallatah, A., Jones, S., & Kohli, D. (2018). Mapping Informal Settlement Indicators using Object Oriented Analysis in the Middle East. *International Journal of Digital Earth* Volume 12 , 802-824.DOI:10.1080/17538947.2018.1485753.
- Fallatah, A., Jones, S., Wallace, L., & Mitchell, D. (2022). Combining Object-Based Machine Learning with Long-Term Time-Series Analysis for Informal Settlement Identification. *Remote Sensing*, 14(5), 1226. MDPI AG. Retrieved from <http://dx.doi.org/10.3390/rs14051226>
- Fam, S.-F.; Ismail, N.; Maukar, A.; Yanto, H.; Prastyo, D.; Chuan, Z.L. (2018). Weighting method in the construction of area deprivation indices. *J. Fundam. Appl. Sci*, 10, 2655–2668.

- Farrington, J., Ramasut, T., & Walker, J. (2002). *Sustainable Livelihood Approaches in Urban Areas: General Lessons, with Illustration from Indian Cases Cities*. Stockholm: Swedish International Development Cooperation Agency.
- FDRE [Federal Democratic Republic of Ethiopia]. (2009, May 6). Federal Negarit Gazeta. Ethiopian Building Proclamation--page 4673 Corrigendum No.4/2009 15th year No.31. Addis Ababa, Ethiopia: The Federal Democratic Republic of Ethiopia. Retrieved from <https://www.ilo.org/dyn/natlex/docs>.
- FDRE. (2014, February 21). Federal Negarit Gazeta. Proclamation No.818/2014: Urban land Holding Registration Proclamation--page 7265 20th year No 25. Addis Ababa: Ethiopian Federal Democratic Republic. Retrieved from <https://chilot.files.wordpress.com/2014/04/proclamation-no-818-2014.pdf>.
- FDRE. (2018). *Enhancing Economic Development and Job Creation in Addis Ababa: The Role of the City Administration*. Danvers: World Bank.
- FDRE. (2020). *The City of Addis Ababa: Performance Assessment Report*. Washington, DC, USA: World Bank Group.
- Fegue, C. (2007). *Informal Settlement Planning Theories and Policy Making in Sub-saharan Africa-From Site to People: A critical Evaluation of Operations 'MURAMBATSVINA' AND 'GARIKAI' IN ZIMBABWE*. Dev. Plan Vol.2 (4), 445-460.
- Filmer, D.; Pritchett, L. (1998). Estimating wealth effects without expenditure data or tears: With an application to educational enrollment in the state of India. In *Targeting Deprivations through Qualitative and Quantitative Indicators*[Master's thesis, University of Twente]. Enschede, The Netherlands: Julia, P.R., (Ed.), SSRN e-library.
- Fisher, T., Gibson, H., Abdar, M., Posa, M., Salimi-Khorshidi, G., Hassaine, A., & Rahim, K. (2022). *Uncertainty-Aware Interpretable Deep Learning for Slum Mapping and Monitoring*. Retrieved from <https://doi.org/10.3390/rs14133072>.
- Florence, B., Vanek, J., & Chen, M. (2019). *Women and Men in the Informal Economy: A statistical brief*. UK, Manchester: WIEGO.
- Fontana, C. (2016). *Hernando de Soto on Land Titling: Consensus and Criticism*. *Next Generation Planning*, 3, 36–48. <https://doi.org/10.24306/plnxt.2016.03.003>.
- Frost, J. (2017, September 18). *Statistics by Jim: making Statistics Intuitive*. Retrieved from *Benefits of Welch's ANOVA Compared to the Classic One-Way ANOVA*: <https://statisticsbyjim.com/anova/welchs-anova-compared-to-classic-one-way-anova/>.
- Ganesh, T. (1986). *Reliability and Validity Issues in Research*. In L. Crocker, & J. Algina, *Introduction to Classical and Modern Test theory*. Philadelphia: Harcourt Brace Jovanovich College.
- Ganesh, T. (1991). *Reliability and Validity Issues in Research*. In R. F. Devellis, *Scale Development: Theory and Applications*, Applied Social Research Method Series 26. Newbury Park: Sage.
- Gebresilassie, H. Y. (2019). *Ethiopia's Urban Productive Safety Net Programme: Its Impact on Households' Food Insecurity*. Unpublished manuscript. Adigrat: Adigrat University.
- Graciela Tonon (2018) *Communities and Capabilities*, *Journal of Human Development*.
- Geoffrey , P., & Alain , D.-L. (2012). *Security of Tenure-Types, Policies, Practices and Challenges*. In UN-Habitat, *Setting up a Global Monitoring System on Security of Tenure*. Nairobi: Special Rapporteur on 22-23 October 2012.
- Gizem, C., & Fulin, B. (2013). *Implication of Socio Spatial Segregation in Urban Theories*. *Planlama* 2013 23(3); Istanbul Technical University, 153-161.
- Gordon, D. (1995). *Census-based deprivation indices: Their weighting and validation. The interplay of policy and Methods*. In Cecilia, W., (Ed.), *Indicators for Urban and Regional Planning* (pp. S39–S44). Oxfordshire, UK: Routledge (Suppl. 2).
- Glassman, B. (2019). *Multidimensional Deprivation in the United States*. Suitland, Maryland, USA: United States Census Bureau.
- Grace-Martin, K. (2023, January). *The analysis factor*. Retrieved from *The fundamental difference between principal component analysis and factor analysis*: <https://www.theanalysisfactor.com/the-fundamental-difference-between-principal-component-analysis-and-factor-analysis/>.
- Graciela Tonon (2018) *Communities and Capabilities*, *Journal of Human Development and Capabilities*, 19:2, 121-125, DOI: 10.1080/19452829.2018.1454288.
- Gram-Hansen, B., Helber, P., Varatharajan, I., Azam, F., Coca-Castro, A., Kopackova, V., & Biliniski, P. (2019). *Mapping Informal settlements in Developing Countries using Machine Learning and Low-Resolution Multispectral data*. *AAAI/ACM Conference on AI, Ethics, and Society (AIES 2019)*. Cornell University. DOI: 10.1145/3306618.3314253.
- Grant, U. (2010, December). *Spatial Inequality and Urban poverty traps*. chronic Poverty research Center ODI Working Paper 326, p. ODI Working Paper 326.
- Greene, R. (1991). *Poverty Concentration Measures and the Urban Underclass*. In W. B. Group, *The Urban Poverty in Ethiopia: A Multifaceted and Spatial Perspective* (pp. Vol 67, No.3, 240-252). *Economic Geography*.

- Guo, X., Zhang, C., Luo, W., Yang, J., & Yang, M. (2020). Urban Impervious Surface extraction based on multi-features and random forest. *IEEE Access* Volume (8). Retrieved from DOI: 10.1109/ACCESS.2020.3046261.
- Habitat for Humanity Great Britain. (2017). Slum Housing in Ethiopia: How to Rebuild a Capital City. Available online: <https://www.habitatforhumanity.org.uk/blog/2017/11/slum-housing-ethiopia> (accessed on 15 March 2022).
- Hacker, K. P., Costa, F., Seto, K. C., Jason, C., Mitermayer, R. G., KO, A. I., & Diuk-Wasser, M. A. (2013). Urban Slum Structure: . *International Journal of Health Geographics: integrating Socio-economic and land cover data to model slum evolution in Salvador, Brazil*, 1-12.
- Hailu, Zerfu. 2016. Land Governance Assessment Framework Implementation in Ethiopia. World Bank, Washington, DC. © World Bank. <https://openknowledge.worldbank.org/handle/10986/28507> License: CC BY 3.0 IGO.”
- Hamza, A. (2023, April 17). The expansion of Informal settlements. Retrieved from Ethiopian Business: <https://ethiopianbusinessreview.net/the-expansion-of-informal-settlements/>.
- Hedman, L., & Van Ham, M. (2021). Three Generations of Intergenerational Transmission of Neighborhood context. *Social Inclusion* Vol (9) issue 2, 129-141 , 129-141. [Internet]. Uppsala, Sweden: Uppsala University; 2021. Available from: <http://dx.doi.org/10.17645/si.v9i2.373>.
- Heisel, F., & Kifle, B. (Directors). (n.d). A night on Addis Ababa’s periphery: A night on Addis Ababa's periphery: Spaces the documentary series [Motion Picture]. Retrieved from _Spaces / Documentaries | Materializing Spaces – a day in Addis Ababa’s periphery (spacesmovie.com).
- Herve, A. (2003). Factor rotation in factor analysis. In *The Encyclopedia of Social Science Research Methods*; Lewis-Beck, M., Bryman, A., Futing, T.; Retrieved from *Factor Rotation in Factor Analysis*; Sage: Dallas, TX 75083–0688, USA. Available online: <http://www.utdallas.edu/herve> (accessed on 14 February 2021).
- Hirschfield, A. (1989). The study of poverty and deprivation in developing countries:a selective review of data sources, approaches and analytical techniques. *The Urban Research and Policy Evaluation Regional Research Laboratory Working Paper 2*. Liverpool: University of Liverpool.
- Hitchcock, G., & Hughes, D. (2003). Research and the Teacher (second Edition). In K. Louis, M. Lawrence, & M. Keith, *Research Design: Qualitative, Quantitative, and Mixed Method Approaches*(6th edition). London: Routledge.
- Hoffman, J. I. (2015). Biostatistics for Medical and Biomedical practitioners. Academic Press, 723-725. Retrieved from <https://doi.org/10.1016/B978-0-12-802387-7.17001-5>.
- Hohmann, R. (2014). Regenerating deprived urban areas: A cross-national analysis of area-based initiatives. Bristol, UK: Policy Press. Available online: <https://doi.org/10.1332/policypress/9781447310785.001.0001> (accessed on 24 June 2019).
- Huang, W., Tang, H., & Xu, P. (n.d.). OEC-RNN: Object Oriented Delineation of rooftops with edges and corners using the recurrent neural network from the aerial images. *IEEE Trans. Geosci.Remote sense* (60), 1-12. *Remote Sens*, 60, 1–12. doi:10.1109/TGRS.2021.3076098.
- IBM SPSS Modeler. (2021, 08 17). Omnibus test. Retrieved from <http://www.ibm.com/docs/en/spss-modeler>.
- ILO [International Labor Organization]. (2021). World Social Protection Report 2020-22: Social protection at cross roads in pursuit of better future. Geneva: ILO.
- Issa, E.E. (2021). Life in a slum neighborhood of Addis Ababa, Ethiopia: Morphological facts and their dysfunctions. *Heliyon*, 7(1), e07139. Available online: <https://doi.org/10.1016/j.heliyon.2021.e07139> (accessed on 10 December 2022).
- Iverson, T., & Soskice, D. (2001). An asset theory of social policy preference. *American Political Science Review* Volume 94 (4), 875-893.<http://www.jstor.org/stable/311719>.
- Jayamohan, M. K., & Amenu, T. K. (2014). Gender and Poverty-An Analysis of Urban Poverty in Ethiopia. *Development Studies Research*, 233–243. <https://doi.org/10.1080/21665095.2014.917053>.
- Jiayi Li, Xin Huang, Lilin Tu, Tao Zhang & Leiguang Wang (2022) A review of building detection from very high resolution optical remote sensing images, *GIScience & Remote Sensing*, 59:1, 1199-1225, DOI: 10.1080/15481603.2022.2101727
- Jones, P. (2017). Formalizing the Informal: Understanding the position of Informal Settlements and Slums in Sustainable Urbanization policies and Strategies in Bandung, Indonesia. *Sustainability* 9(8), 1436, 2-27. Retrieved from <https://doi.org/10.3390/su9081436>.
- Kaiser, H. F. (1974) An index of factorial simplicity. *Psychometrika*, 39(1), pp. 31-36
- Kalali, A., Richerson Sarah, Ouzunova, E., Westphal, R., & Miller, B. (2019 Volume (29)). Chapter 16 - Digital Biomarkers in Clinical Drug Development. *Handbook of Behavioral Neuroscience*, 229-238.
- Kaliyadan , F., & Kulkarni, V. (2019). Types of Variables, Descriptive Statistics, and Sample Size. *Indian Dermatol Online* 10 (1), 82-86. Retrieved from doi: 10.4103/idoj.IDOJ_468_18. PMID: 30775310; PMCID: PMC6362742.
- Kamalipour, H. (2016). Forms of Informality and adaptations in Informal Settlements. *Archnet IJAR Int Archit.Res* 10 (60).

- Kanbur, R.; Venable, A. (2005). Introduction: Spatial inequality and development. *J. Econ. Geogr.* 5, 1–2. Available online: <http://hdl.handle.net/10.1093/jnlecg/lbh059>.
- Kassahun, S. (2010). Urbanization and its Impact on the Making of Informal Settlements in Addis Ababa. In J. Fransen, S. Kassahun, & M. Van Dijk (Eds.), *Formalization and in formalization Process in Urban Ethiopia: Incorporating Informality* (pp. 71–83). Maastricht: SHAKER Publishing.
- Kassahun, S., & Tiwari, A. (2012). Urban Development in Ethiopia: Challenges and Policy Responses. *The IUP Journal of Governance and Public Policy*, 7(1), 60–75.
- Kloosterboer, M.H.(2019). *The New Addis Ababa: Shanty Town or Global City: An Assessment of Large-Scale Inner-City Renewal, Redevelopment, and Displacement for the Construction of a ‘New’ Addis Ababa*[Doctoral Dissertation, University of Glasgow]. Glasgow, Scotland: University of Glasgow.
- koh, S. Y. (2020). International Encyclopedia of Human geography. In A. Kobayashi. Elsevier Ltd 2nd edition.
- Kohli, D., Sliuzas, R., Kerle, N., & Stein, A. (2012a). An ontology of slums for image-based classification. *Computer, Environment and Urban Systems*, 154-163. <https://doi.org/10.1016/j.compenvurbsys.2011.11.001>.
- Kohli, D., Kerle, N., & Sliuzas, R. (2012b). Local Ontology for object-based slum identification and classification. *Proceeding of the 4th GEOBIA May 7-9* (p. 201). Rio de Janeiro: GEOBIA.
- Koroso, N.H.; Lengoiboni, M.; Zevenbergen, J.A. (2021). Urbanization and urban land use efficiency: Evidence from regional and Addis Ababa Sattelite Cities, Ethiopia. *Habitat Int.*117 (1), 102437. <https://doi.org/10.1016/j.habitatint.2021.102437>.
- kothari, C. R. (2007). *Quantitative techniques*. New Delhi: UBS Publishers LTD.
- Kuffer, M. (2017). *Spatial pattern of Deprivations in Cities of the Global South in very high resolution imagery*. Enschede, the Netherlands: ITC Dissertation Number 304.
- kuffer, M., Grippa, T., Persello, C., Taubenböck, H., Pfeffer, K., & Sliuzas, R. (2022). Mapping the Morphology of Urban Deprivations: The Role of Remote Sensing for Developing Global Slum Repository, Chapter 14. In X. Yang, *Urban Remote Sensing: Monitoring, Synthesis, and Modeling in the Urban Environment* (pp. 305-323). John Wiley & Sons Ltd.
- Lakisha, D. T. (2012). *Towards Practical Guidelines for the Design of Affordable, net Zero Communities in Peri-Urban Ethiopia*. Greensboro: The Associate School of Construction.
- Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *biometrics*, 159-174.
- Lasse, K. (2011). *The Sustainable Livelihood Approach to Poverty Reduction: An Introduction*. Swedish International Development Cooperation Agency.
- Lemma, T., Sliuzas R., & Kuffer., M. (2006). A participatory approach to monitoring slum conditions: An example From Ethiopia. *Participatory Learning and Action*, 59-65.
- Leon, A. C. (1998). Descriptive and Inferential Statistics (Volume 3). In A. S. Bellack, & M. Hersen, *Comprehensive Clinical Psychology* (pp. 243-285). Elsevier Science Ltd.
- Leonita., G Kuffer, M., Sliuzas, R., & Persello, C. (2018). Machine Learning Based Slum Mapping in Support of Slum Upgrading Programs: the case of Bandung City, Indonesia. *remote sensing Volume(10) 1522*, 2-26. Retrieved from doi:10.3390/rs10101522.
- Liddle, B. (2017). Urbanization and inequality/poverty. *Urban Science* 1(4), 35, 2-7. Retrieved from HYPERLINK "<https://doi.org/10.3390/urbansci1040035>" <https://doi.org/10.3390/urbansci1040035> .
- Lienert, J., & Burger, P. (2015). Merging capabilities and livelihoods: Analyzing the use of biological resources to improve well-being. Retrieved from *Ecology and Society*, 20 (2) <https://www.jstor.org/stable/26270215>.
- Lilford, R., Kyobutungi, C., Ndugwa, R., Sartori, J., Watson, S. I., Sliuzas, R., . . . Ezeh, A. (2012). Because space matters: conceptual framework to help distinguish slum from non-slum urban areas. *Comput. Environ. Urban System* 36, 154-163.
- Levitas, R. (2006). *The Concept and Measurement of Social Exclusion*. Bristol: Policy Press.
- Levitas, R., Pantazis, C., Fahmy, E., Gordon, D., Loyd , E., & Patsios, D. (2007). *The multidimensional analysis of social exclusion*. Bristol, United Kingdom: University of Bristol. Retrieved from <https://dera.ioe.ac.uk/6853/1/multidimensional.pdf>.
- Lewis, O. (1966). *The Culture of Poverty*. Retrieved from *Scientific American*, 215(4), 19–25 <https://www.jstor.org/stable/24931078>.
- Logan, J. R. (1976). Logan on Molotch and Molotch on Logan: Notes on the Growth Machine-Towards a comparative political economy of place. *American Journal of Sociology* 82(2), no.2, 349-352.<http://www.jstor.org/stable/2777098>.
- Lojkin, J. (1979). El marxismo, el Estado y la cuestión urbana. In M. Lucia, & B. Machado, *Urban Segregation: A Theoretical Approach*. Mexico: Siglo.
- Loyd CT, Chamberlain H, Kerr D, Yetman G, Pistolesi L, Stevens FR, Gaughan AE, Nieves JJ, Hornby G, MacManus K, Sinha P, Bondarenko M, Sorichetta A, Tatem AJ. (2019). Global spatio-temporally harmonised datasets for producing high-resolution gridded population distribution datasets. *Big Earth Data*. Jun 18;3(2):108-139. doi: 10.1080/20964471.2019.1625151. PMID: 31565697; PMCID: PMC6743742.

- Lu, Z. (2003). Measuring Urban Poverty: Case Study Wuhan [master's Thesis, International Institute for Geoinformation Science and Earth Observation]. Enschede, The Netherlands: International Institute for Geoinformation Science and Earth Observation. Available online: https://webapps.itc.utwente.nl/librarywww/papers_2003/msc/upla/lu_zhoujie.pdf (accessed on 7 March 2019).
- Lucia, M., & Machado, B. (2017, Nov 5). Urban Segregation: A Theoretical Approach. Retrieved from Observatoridasmetrosoles.ufrj.brazil: <http://www.observatoridasmetrosoles.ufrj.brazil>.
- MacCallum, R. C., Widaman, K. F., Zhang, S. and Hong, S. (1999). Sample size in factor analysis. *Psychological Methods*, 4(1), pp. 84-99.
- Mahiteme, Y. (2007). Carrying the Burden of Long Term Ineffective Urban Planning: An Overview of Addis Ababa Successive Master Plan and their implications on the growth of the cities: Working Paper on Population and Land use Change in Central Ethiopia., nr.7, Acta Geographica-Trondheim, Series A, No.16.
- Mahiteme, A. (2014). Housing in Addis Ababa. In UN-Habitat, The State of Addis Ababa. Addis Ababa: The World Bank and Danish Trust Fund.
- Majale, M. (2002). TOWARDS PRO-POOR REGULATORY GUIDELINES FOR URBAN UPGRADING:A Review of Papers presented at the International Workshop at Bourton-On-Dunsmore, May 17-18, 2001. Warwickshire, United Kingdom: Intermediate Technology Development Group (ITDG), Schumacher Centre for Technology and Development.
- Mario, L., & Sonia, B. (2001). Socio-Spatial Segregation and Urban Land Regulation in Latin American Cities. International Seminar on Segregation in the City held from July 26-28,2001. Cambridge: Lincoln Institute of Land Policy.
- Martinez, J. (2005). Monitoring intra-Urban Inequality with GIS-based Indicators: With a Case Study in Rosario, Argentina [Doctoral Dissertation, International Institute of Geoformation Science and Earth Observation (ITC)]. ITC, Enschede, The Netherlands. <https://research.utwente.nl/en/publications/monitoring-intra-urban-inequalities-with-gis-based-indicators-wit>.
- Masud, P. R. (2015). Mapping Urban Poverty and Deprivations:the case od Rajshahi City. Research Gate, 85-97.
- Matarira, D., Mutanga, O., Naidu, M., & Mushore, T. D. (2023). Characterizing Informal Settlement Dynamics using google earth engine and intensity analysis in Durban metropolitan area, South Africa: Linking pattern to process. *Sustainability* 15 (3). Retrieved from <https://doi.org/10.3390/su15032724> (registering DOI).
- Mathenge, C. W. (2011). Application of Object Oriented Image Analysis in Slum Identification and Mapping : the case of Kisumu, Kenya [Master's thesis, University of Twente]. Enschede, the Netherlands: University of Twente.
- McCormick, K., Neij, K. L., & Anderberg, S. (2012). Sustainable Urban Transformation and the Green Urban Economy. Retrieved from <http://www.springer.com/environment/sustianble+development/book/978-94-007-1968-2>.
- McLennan, D. (n.d). Indices of Deprivations: Mapping the Spatial Distribution of Multiple Deprivations at Small Area Level and Their Uses for Targeting Area-Based Regeneration Policies. Oxford, UK: the University of Oxford. Available online: <https://www.oecd.org/regional/regional-policy> (accessed on 13 August 2022).
- McLennan, D.; Noble, S.; Noble, M.; Plunkett, E.; Wright, G.; Gutacker, N. (2019). The English Indices of Deprivation 2019. London, UK: Ministry of Housing, Communities, and Local Government.
- McLeod, R. (2001). The impact of Regulations and Procedures on the Livelihood and Asset Base of the Urban poor: a financial perspective. paper Presented at the International Workshop on Regulatory Guidelines for Urban Upgrading. Bourton-On-Dunsmore.
- Mengual-Macennle, N., Pedro J, J., & Rafael , G. (2015). Multivariate analysis in thoracic research. *Journal of Thoracic disease* 7(3).DOI: 10.3978/j.issn.2072-1439.2015.01.43.
- Messer, N., & Townsley, P. (2003). Local Institutions and Livelihoods: Guidelines for Analysis. Rome: Food and Agriculture Organization of The United Nations.
- Ministry of Federal Affairs(MFA). (2005). Urban Development Policy: Approved by Council of Ministers. Addis Ababa: Ministry of Federal Affairs.
- Ministry of Finance and Economic Development (MOFED). (2013). Development and Poverty in Ethiopia 1995/96-2010/11 ETC. Addis Ababa, Ethiopia: Ministry of Finance and Economic Development.
- MOLS [Ministry of Labors and Skills]. (2012). National Social Protection Policy of Ethiopia. Addis Ababa: MOLS (Ministry of Labors and Skills).
- Ministry of Urban Development, Housing and Construction (MUDHC). (2003). Urban Land Development and Management Policy. Addis Ababa: MUDHC.
- Ministry of Urban Development and Housing (MUDH). (2015). National Urban Development Spatial Plan. Addis Ababa, Ethiopia: Egis International in association with IAU-IDF & Urban Lyon.
- Minwuyelet, M. (2005). City Expansion, Peri-urban Settlements and Policy Implications in Addis Ababa: The Case of Kolfe-Keranyo Sub-city. Working Paper on Population and Land Use Change in Central Ethiopia, nr. 2, Acta Geographica-Trondheim, 2-28.
- Mirjam, A.; Alastair, L.; Maria, Y.; Travassos, C.; Ruth, D. (2020). Creating small area deprivation indices: A guide for stages and options. *Epidemiol Community Health*, 74, 20–25.

- Mitilin, D.; Satterthwaite, D. (2004). Empowering Squatter Citizen an Urban Poverty Reduction. International Institute for Environment and Development, London, UK: Earthscan.
- Moser, C. (2008). Asset and Livelihood: A Framework for Asset Based Social Policy. In I. A. Dani, & C. Moser (Eds.), *Asset, Livelihood and Social Policy* (pp. 43–81). Washington, DC: New Frontiers of Social Policy, The World Bank.
- Moser, C., & Dani, A. A. (2008). *Assets, Livelihoods and Social Policy*. Washington DC: World Bank Group Doi: 10.1596/978-0-8213-6995-1.
- Morse, S., & Mcnamara, N. (2013). Sustainable Livelihood Approaches: A Critique of Theory and Practice. Retrieved from Springer Science Business Media: <http://www.Springer.com/978-94-007-6267-1>.
- Muller, I., Taubenbock, H., kuffer, M., Wurm, M. (2020). Misperception of Predominant Slum Locations? Spatial Analysis of Slum Locations in Terms of Topography based on Earth Observation Data. *MDPI Remote Sens* 2020 12.doi:10.3390/rs12152474.
- Murray, S.C. (2015). Basic Facts on Concentrated Poverty. Center on Budget and Policy Priorities. Available online: <https://www.cbpp.org/sites/default/files/atoms/files/11-3-15hous2.pdf> (accessed on 7 December 2021).
- Narvaez, L.; Penn, A.; Griffiths, S. (2013). Spatial Configuration and Bid Rent Theory: How Urban Space Shapes The Urban Economy. *Proceedings of The Ninth International Space Syntax Symposium*, Sejong University, Seoul, Republic of Korea; pp. 1–19. Available online: <https://www.researchgate.net/publication/315718155> (accessed on 17 September 2022).
- National Centers for Research Methods (NCRM). (2023, February 12). Using Statistical Regression method in educational research: The SPSS Logistic Regression Output. Retrieved from 4.12. The SPSS Logistic Regression Output: <https://www.restore.ac.uk/>.
- Nega, F., & Edris, H. (2016, February). Small and Medium Enterprise Access to Finance in Ethiopia: Synthesis of Demand and Supply. The Horn Economic and Social Policy Institute (HESPI) Working Paper 01/16, 1-39. (2017). Ethiopia.
- Neuman, W. L. (2000). *Social Research Methods:Qualitative-Quantitative Research Methodologies*. In C. W. John, *Research Design: Qualitative, Quantitative and Mixed Method Approaches*. Boston: Allyn and Bacon.
- Neumark, D.; Simpson, H. (2014). Place-Based Policies. NBER Working Paper 20049. 1–76. Available online: <https://doi.org/10.3386/w20049> (accessed on 7 September 2020).
- Neumark, D., & Helen, S. (2014, April). Place-based policies. NBER Working Paper No. 20049, pp. 1-76. Retrieved from <https://www.nber.org/papers/w20049>.
- Nikolopoulos, K. (2022a, August 11). Scribbr. Retrieved from What is purposive sampling? definition and examples: <https://www.scribbr.com/methodology/purposive-sampling>.
- Nikolopoulos, K. (2022b, August 10). Scribbr. Retrieved from What is convenient sampling? definition and examples: <https://www.scribbr.co.uk/research-methods/conveniencce-sampling-method>.
- Noble, M.; Babita, M.; Barnes, H.; Dibben, C.; Magasela, W.; Noble, S.; Ntshongwana, P.; Phillips, H.; Rama, S.; Roberts, B.; et al. (2006). *The Provincial Indices of Multiple Deprivation for South Africa 2001*. Oxford, UK, 2006: University of Oxford, 2006.
- Oliveira, V. (2020). *Urban Morphology: an introduction to the study of the physical form of cities*. Springer. DOI:10.1093/OBO/9780190922481-0004.
- ORAAMP (Office for the Revision of Addis Ababa Master Plan). (2001). Centrality. In Tesfaye, M., (Ed.), *Housing Strategies in Inner City Areas: The case of Low-Income Housing in Inner-City Addis Ababa*; Addis Ababa, Ethiopia: Addis Ababa University.
- Osberg, L. (2001). *International Encyclopedia of the Social and beavioral science*. In N. J. Smelser, & P. B. Baltes. Elsevier.
- Oyinloye, M., Owoeye , J. O., & Ogunlade, S. (2018). Geo-spatial analysis of Informal settlements on Land Use/Land Cover change areas of Osogobo, Nigeria. *American Journal of Environment and Sustainable Development* Volume 3 (3), 55-70.
- Pacione, M. (2001). *Urban Geography: A Global Perspective*. London: Routledge.
- Pacione, M. (2009). *Urban Geography: Global Perspective*, 3rd ed. London, UK; New York, NY, USA: Routledge, Taylor and Francis.
- Pankhurst, R. (1961). Menelik and the Foundation of Addis Ababa. *The Journal of African History* Vol 2 (1), 103-117.
- Parsons, J. A. (2018). *Encyclopedia of Survey research Methods: The SAGE Encyclopedia of communication research methods*. SAGE. Retrieved from DOI:<https://doi.org/10.4135/9781412963947>.
- Pascal, M., & Pierre, P. (2013). Spatial Segregation and Urban Structure. RIETI Discussion Paper Series 13-E-056 (pp. 1-39). RIETI, Research Institute of Economy, Trade and Industry.
- Patel, A.; Shah, P. (2020). Beauregard, B.E. Measuring multiple housing deprivations in urban India using slum severity index. *Habitat Int.* 2020, 101, 102190.
- Pawar , N. (2020). *Research Methodology*. In *Type of Research and Type of Research design* (pp. 46-57). Haryana, India: KD Publications. Retrieved from <https://www.kdpublications.in>

- Payne, G., & Majale, M. (2004). *The Urban Housing Manual: Making Regulatory Frameworks Work for the Poor*. London: Earth Scan.
- Payne, G., Rakodi, C., & Durand-Lasserve, A. (2009). The Limits of Land Titling and Home Ownership. *Environment and Urbanization*, 21(443), 443–462. <https://doi.org/10.1177/0956247809344364>.
- PDC (Planning and Development Commission). (2020). *10-years Development Plan: A Pathway to Prosperity 2021–2030*. Addis Ababa: Planning and Development Commission, Federal Democratic Republic of Ethiopia.
- Rebolj, B. A. (2013). The Case Study as a Type of Qualitative Research. *Journal of Contemporary Educational Studies*, 1, 28–43.
- Pishghadam, R.; Noghani, M.; Zabihi, R. (2011). The construct validation of a questionnaire of social and cultural capital. *Engl. Lang. Teach*, 4, 195–203. <https://doi.org/10.5539/elt.v4n4p195>.
- Qiu, N.; Jianquan, C.; Tianjie, Z. (2022). Spatial disparity and Structural inequality in disability patterns across Tianjin municipality: A multiple deprivation perspective. *Habitat Int.*, 130, 102685. Available online: <https://doi.org/10.1016/j.habitatint.2022.102685>.
- Rebolj, B. A. (2013). The Case Study as a Type of Qualitative Research. *Journal of Contemporary Educational Studies*, 1, 28–43.
- Remote Sensing and GIS applications. (2023, February 18). Lesson 13 Classification Accuracy Assessment. Retrieved from <http://ecoursesonline.iasri.res.in/mod/page/view.php?id=2066>.
- Richard, P. (1975). Inequality and Poverty: A Marxist Geographic Theory. *Annals of the Association of American Geographers*, Vol.65, No.4, Taylor and Francis, 564-571.
- Robeyns, I., & Morten, B. F. (2021). The Capability Approach, *The Stanford Encyclopedia of Philosophy*. In N. Edward, *Encyclopedia of Philosophy*. Winter. <https://plato.stanford.edu/archives/win2021/entries/capability-approach/>.
- Rogerson, P.A. (2006). *Statistical Methods for Geography a student’s guide* (2nd ed.). Thousand Oaks, California, USA: SAGE.
- Room, G. (1995). Beyond the Treshold: The Measurement and Analysis of Social Exclusion. In W. Cecilia, *Indicators for Urban and Regional Planning: the Interplay of Policy and Methods*. Bristol: Policy Press.
- Sabine, W.; Ali, M.; Peter, S. (2021). Place-based development and Spatial Justice. *Eur. Plan. Stud.* 30, 791–806. <https://doi.org/10.1080/09654313.2021.1928038>.
- Samper, J., Shelby, J. A., & Behray, D. (2020). The Paradox of Informal Settlement revealed in an Atlas of Informality: Finding from Mapping Growth in the most common yet unemployed forms of Urbanization. *Sustainability*.doi: 10.3390/su12229510.
- Saunders, J. (1998). Weighted Cenus based Deprivation Indices: their use in small areas. *Journal of Public Health Medicine* 20(3), 253-260.
- SDG. (2018). Goals and Targets from the 2030 Agenda for Sustainable Development. Available online: sustainabledevelopment.un.org (accessed on 13 October 2022).
- SDG Tracker. (2019). Sustainable Development Goal 11. Retrieved from [Make Cities Inclusive, Safe, Resilient, and Sustainable](http://sdg-tracker.org/cities/target). Available online: <http://sdg-tracker.org/cities/target> (accessed on 15 April 2020).
- Sen, A. (1995). *The Political Economy of Targeting: Public Spending and the poor*. Washington DC: D. van de Walle and K. Nead. Serrat, O. (2017). *Knowledge Solutions: Tools, Methods*
- Serrat, O. (2017). The Sustainable Livelihoods Approach. In: *Knowledge Solutions*. Springer, Singapore. https://doi.org/10.1007/978-981-10-0983-9_5.
- Sheilah, M., Tamsin, R., & Julian, W. (2001). *Sustainable Urban Livelihoods: Concepts and Implications for Policy*. Retrieved from No. 112. *Sustainable Urban Livelihoods: Concepts and Implications for Policy*. https://www.ucl.ac.uk/.../DPU_Meikle_Sustainable_Urban%20Livelihoods.pdf. Accessed 17 August 2019.
- Sherraden, M., & Rank, M. (2008). *Asset-based Policies and Financial Services: Towards Fairness and Inclusion*. “Old Assumptions, New Realities: (pp. 1-55). Washington DC: West Coast Poverty Center and the University of Washington.
- Shieh, Y.-N. (2003). Early use of bid rent functions. In *Wikipedia, Bid Rent Theory*. *Urban Studies: Volume 40*, pp. 791–795. <https://doi.org/10.1080%2F0042098032000065308>.
- Shifa, M.; Leibbrandt, M. (2021). *Spatial Inequality in Sub-Saharan Africa; African Center of Excellence for Inequality Research (ACEIR) Working Paper Series; African Center of Excellence for Inequality Research (ACEIR): Cape Town, South Africa*, pp. 1–45.
- Shinns, L., & Lyne, M. (2002). Symptoms of Poverty within a Group of Land Reform Beneficiaries in the Midlands of KwaZulu Natal: Analysis and Policy Recommendations. In T. Ephrem, *Livelihood and Food Security in the Small Urban Centers of Ethiopia: The case of Durame, Welenchiti and Debresina Towns*. Addis Ababa [Doctoral Dissertation, Addis Ababa University]. Addis Ababa, Ethiopia: Addis Ababa University.
- Simplilearn. (2023, March 31). Descriptive versus Inferential Statistics: key differences and measurement techniques. Retrieved from https://www.simplilearn.com/difference-between-descriptive-inferential-statistics-article#types_of_inferential_statistics.

- Singh, P., Singh, N., Singh, K. K., & Singh, A. (2021). Chapter 5 - Diagnosing of disease using machine learning,. In K. K. Singh, M. Elhoseny, A. Singh, & A. A. Elngar, *Machine Learning and the Internet of Medical Things in Healthcare* (pp. 89-111). Academic Press. ISBN 9780128212295. retrieved from: <https://doi.org/10.1016/B978-0-12-821229-5.00003-3>.
- Sliuzas, R., & Kuffer, M. (2008). Analyzing the Spatial Heterogeneity of Poverty Using Remote Sensing: Typology of Poverty Areas Using Selected RS Based Indicators. *Remote Sensing-New Challenges of High Resolution*, Bochum, 158-167.
- Smith, G. (1999). Area-based initiatives: The rationales and options for area targeting. In *Monitoring intra-urban Inequalities with GIS-Based Indicators* [Doctoral dissertation, International Institute of Geofomation Science and Earth Observation, Enschede, the Netherlands]. Martinez, A.J., Ed.; Centers for Analysis of Social Exclusion, London School of Economics: London, UK.
- Solomon, M., & Mcleod, R. (2004). Feasibility Study for the Application of Community Lead Infrastructure Finance Facility Operations in Ethiopia. In A. Y. Elias, *Revisiting Slums, Revealing responses.* : Homeless International.
- Soma, H., Sukhwani, V., & Shaw, R. (2020). An approach to determining the linkage between livelihood assets and the housing conditions in urban slums of Dhaka. *Journal of Urban Management*. <https://doi.org/10.1016/j.jum.2021.08.006>.
- Sori, N. D. (2012). Identifying and Classifying Slum Development stages from Spatial data [Master's thesis, Twente University]. Enschede, The Netherlands: University of Twente. UPM_Negera Dinsa Sori_23095.pdf (utwente.nl)
- Southampton Data Observatory. (2020). Deprivation and Poverty in Southampton. Available online: <http://data.Southampton.government.UK> (accessed on 5 May 2022).
- Stanford Encyclopedia of Philosophy. (2011). The capability approach. In A. Sen, *Inequality Re-examined*. Oxford: Clarendon Press. Retrieved from <https://plato.stanford.edu/entries/capability-approach>.
- Statistics Data. (2023, February 19). Toppr. Retrieved from <https://www.toppr.com/guides/maths/statistics/data/>.
- Stoke, C. J. (1962). A Theory of Slum: Land Economics. In A. Gossaye, *Inner City renewal in Addis Ababa: The Impact of Resettlement on Socio-Economic and Housing Situations of Low-Income Residents* (pp. 187-197). Trondheim: Land Economics Vol.38. No.3,187-197.
- Suleman, I.; Nketiah-Amponsah, E.-A.; Codjoe, E.A.; Akua, J.; Andoh, N. (2019). Urbanization and Income Inequality in Sub-Saharan Africa. *Sustain. Cities Soc.*, 48 (1), 101544.
- Talema, A. H. (2023). *Impacts of urban expansion on the livelihoods of local farming communities: The case of Burayu town, Ethiopia*. Retrieved from <https://doi.org/10.1016/j.heliyon.2023.e14061>
- Tarekegn, E. A. (2000). Kitiya, Transformation of low-income housing in Addis Ababa[Doctoral Dissertation, Norwegian university of science and technology]. Trondheim, Norway: Norwegian university of science and technology.
- Terfa, B. K., Chen, N., Zhang, X., & Niyogi, D. (2020). Urbanization in Small Cities and Their Significant Implications on Landscape Structures: The Case in Ethiopia. *Sustainability*, 12(3), 1235. MDPI AG. Retrieved from <http://dx.doi.org/10.3390/su12031235>
- Tesfay, M.W. (2016). The Challenge of Current Upgrading Projects in Addis Ababa, Ethiopia: A Case Study of Chew Berenda Upgrading Project [Doctoral Dissertation, Norwegian University of Science and Technology]. Norwegian University of Science and Technology: Trondheim, Norway.
- Tesfaye, E.K. (2019). Peri-Urban Land in Ethiopia: Genesis, Dynamic, and Planning [Doctoral Dissertation, Universität Rostock]. Rostock, Germany: Universität Rostock. Available online: <https://www.uni-rostock.de/storages/uni-rostock> (accessed on 13 October 2022).
- Thomas, N., Hendrix, C., & Congalton, R. (2003). A Comparison of Urban Mapping Methods using High Resolution Digital Imagery. *Phtogrammetric Engineering and Remote Sensing* 69(9), 963-972. DOI:10.14358/PERS.69.9.963.
- Tjia, D., & Coetzee, S. (2022). Geospatial information needs for informal settlement upgrading-A review. *Habitat International*. Retrieved from <https://doi.org/10.1016/j.habitatint.2022.102531>.
- Thomas, L. (2020, October 2). Scribbr. Retrieved from What is purposive sampling? definition and examples: <https://www.scribbr.com/methodology/systematic-sampling>.
- Townsend, P. (1979). *Poverty in the United Kingdom*, Penguin: London, UK.
- Townsend, P. (1987). Deprivation: *Journal of Social Policy* 16(2). In W. Cecilia, *Indicator of Urban and Regional PLanning: the Interplay of Policy and Methods* (pp. 125-146). London: Routledge.
- Tufa, D. (2008). Historical Development of Addis Ababa: plan and realities. *Journal of Ethiopian Studies* 41 (1), 27-59.
- Tunstall, R.; Lupton, R. (2003). Is targeting deprived areas an effective means to reach poor people? An assessment of one rationale for area-based funding program case paper 17. In *Targeting Deprivations through Qualitative and Quantitative Indicators*[Master's thesis, University of Twente]. A Case Study of Kisumu, Kenya; Julio, R.P., Ed.; Enschede, The Netherlands: University of Twente.

- Turner, J.C. (1968). Housing Priorities, Settlement Patterns, and Urban Development in Modernizing Countries. In H. M. Tupper, *Urban Morphological Theory and Spatial Differentiation: Residential Land Use from 1948 to 1975 in Santo Domingo, The Dominican Republic* (pp. 167-181). *Journal of American Institute of Planners* 34.
- Turner, J. C. (1969). Uncontrolled Urban Settlement: Problems and Policies. In G. Alan, *The Return of Slum: Does Language Matter* (pp. Volume 31.4, 697-713). Englewood Cliffs, NJ: Prentice_Hall.
- Turner, J. C. (1976). *Housing by People*. London: Maryon Boyars.
- Turner, J. C. (1982). The issue on Self Help and Self Managed Housing. From Ward P.M *Self Help Housing, a Critic*, Mansell, 99-113.
- Turkstra, J.; Raithelhuber, M. (2004). Urban Slum Monitoring. In *Proceedings of the 24th Annual ESRI International User Conference, San Diego, CA, USA, 9–13 August: ESRI Conference Paper No.1667*.
- Turok, E. (2013). People-based versus place-based policy: The 2009 world development report. *Local Econ.* 28, 3–8. <https://doi.org/10.1177/0269094212463787>.
- UNDESA and World Bank Group. (2019). *Sustainable Development Goal 10—Reduced Inequalities: Progress and Prospects*; Geneva, Switzerland: UNDESA and World Bank Group.
- UNDG (United Nations Development Group). (2012). *Integrating Urbanization into the CCA and UNDAF: A guide for United Nations Country teams*. New York: United Nation Development Group Asia and the Pacific. Retrieved from <https://unhabitat.org/sites/default/files/documents/2019-05/undg-a-p-urbanization-final-draft-v7.pdf>.
- UNDP. (1997). *Human Development Report 1997*. New York: Oxford University Press.
- UNDP. (2012). High-level political forum on sustainable development. [https:// sustainabledevelopment.un.org](https://sustainabledevelopment.un.org).
- UNDP. (2016). *Sustainable Urbanization Strategy: UNDP's support to Sustainable, Inclusive and Resilient Cities in the Developing World*. New York: UNDP.
- UNDP. (2017). *Application of the Sustainable Livelihood Frameworks in Development Projects*. Panama City: United Nations Development Program (UNDP). Retrieved from file:///C:/Users/User/Downloads/UNDP_RBLAC_Livelihoods%20Guidance%20Note_EN-210July2017.pdf.
- UNDP Ethiopia. (2018). *Ethiopia's Progress Towards Eradicating Poverty. Implementation of the Third United Nations Decade for the Eradication of Poverty (2018–2027)*. Addis Ababa, Ethiopia: UNDP Ethiopia.
- UNDP. (2013, July 4). *About Ethiopia: UNDP in Ethiopia*. Retrieved July Monday, 2016, from www.et.undp.org/content/ethiopia/en/home/countryinfo.html:
- UN-Habitat. (2003a). *The Challenge of Slums: Global Report on Human Settlements 2003*. London and Sterling, VA: Earthscan Publications Ltd <https://www.un.org/ruleoflaw/files/Challenge%20of%20Slums.pdf>.
- UN-Habitat. (2003b). *Guide to Monitoring Target 11: Improving the Lives of 100 Million Slum Dwellers*. Nairobi: UN-Habitat. <https://unhabitat.org>.
- UN-Habitat. (2011). *Condominium Housing in Ethiopia: The Integrated Housing Development Program*. Nairobi, Kenya: UN-Habitat.
- UN-Habitat(2007). *Enhancing Urban Safety and Security: Global Report on Human Settlement*, UN-Habitat publication, London: Earth Scan.
- UN-Habitat. (2015). *Slum Almanac 2015/16: Tracking Improvement in the Lives of Slum Dwellers*. Nairobi, Kenya: UN-Habitat.
- UN-Habitat III. (2015). *Habitat III Issue papers: Urban and Spatial Planning and Design*. United Nation Conference on Housing and Sustainable Urban Development. Quito: Habitat III.
- UN-Habitat. (2017). *The State of Addis Ababa the Addis Ababa We Want*. Nairobi, Kenya: UN-Habitat.
- UN-Habitat and Global Urban Observatory. (2019). *Monitoring SDG indicator 11.1.1: Global Monitoring of Slums remain a key concern for achieving the right to adequate housing*. UN-Habitat, the Urban SDG Monitoring Series. Retrieved from <http://www.unhabitat.org>.
- UN-Habitat. (2020a). *Urbanization and Cities: Trends of New Global Force*. Retrieved from *Urbanization and Cities: Trends of New Global Force: https://unhabitat.org/sites/default/files/2020/10/chapter_1_urbanization_and_cities.pdf*.
- UN-Habitat.. (2020b). *Caribbean Strategy for Informal Settlement Upgrading: A Guide to Inclusive and Resilient Urbanization*. Nairobi, Kenya: UN-Habitat.
- UN-Habitat. (2020c). *Analysis of Multiple Deprivations in Secondary Cities in Sub-Saharan Africa*. London, UK: UN-Habitat. Available online: <http://Sustainabledevelopment.un.org> (accessed on 17 November 2021).
- UN-Habitat. (2022). *World Cities report 2022: Poverty and Inequality Enduring Feature of Urban Future*. Bangladesh, Dhaka: UN-Habitat.
- UNICEF and UN-Habitat. (2020). *Analysis of Multiple Deprivations in Secondary Cities in Sub-Saharan Africa*. London: UNICEF, UN Habitat and Ministry of Foreign Affairs of the Netherlands.
- United Nations. (2021, December). *New Trends and Innovations in Social Policy*. Retrieved from *United Nations Library: https://doi.org/10.18356/626edf75-en*.
- United Nations. (2023a, February 19). *Goal 11 Make cities and human settlements inclusive, safe, resilient, and sustainable*. Retrieved from <https://unstats.un.org/sdgs/files/metadata-compilation/Metadata-Goal-11.pdf>.

- United Nations. (2023b, February 10). Make Cities and Human Settlements Inclusive, Safe, Resilient, and Sustainable. Retrieved from Goal 11 Sustainable Cities and Communities: <https://unstats.un.org/sdgs/report/2022/goal-11/>.
- Van Domelen, J. (2007). Reaching the poor and vulnerable: Targeting strategies for the social fund and other community-driven programs. World Bank, Washington, DC, USA: Social Protection (SP) Discussion Paper No.0711.
- Van Ham, M., Hedman, L., Manley, D., Coulter, D., & Osth, J. (2014). Intergenerational transmission of neighborhood poverty: an analysis of neighborhood histories of individuals. *PubMed* 39 (3), 402-417. Available from: <http://dx.doi.org/10.1111/tran.12040>.
- Van Ham, M., Tammaru, T., & Janssen, H. (2018). A multi level model of vicious circle of socio-economic segregation. In OECD, *Understanding intra-Urban Inequalities* (pp. 127-146). OECD Publishing. Retrieved from <http://dx.doi.org/10.1787/9789264300385-en>.
- Vatsa, K. (2004). Risk, Vulnerability, and Asset-Based Approach to Disaster Risk Management. *International Journal of Sociology and Social Policy*, 1–48. <https://doi.org/10.1108/01443330410791055>.
- Veriah, R. R. (2018). Classification of Informal Settlements based on their susceptibility to climatic change: A case study of Ahmedabad, India. Ahmedabad: Applied Research Paper.
- Vicki, B., Josiah, M., & Simon, M. (2014). Urban Land Use Regulation: Are home voters Overtaking the Growth Machine. *Journal of Empirical Legal Studies*, Volume 11, Issue 2, 227–265. Retrieved from <http://10.1111/jels.12040>.
- Victor, A. (2017). Course code: Advance Statistical Method in Education: Distinguish between Primary Sources of Data and secondary sources of data. Retrieved from <http://doi.org/10.13140/RG.2.2.24292.68481>.
- Vijaya, K. (2010). Constructing an area-based socioeconomic index: A principal components analysis approach. In *Proceedings of the Early Childhood Intervention Australia (ECIA) 2010 Conference and Community-University Partnership (CUP)*, Canberra, Australia, 20–22 May 2010; University of Alberta (pp. 1–26).
- Vladimirova, K.; Le Blanc, D. (2015). How Well Are the Links between Education and Other Sustainable Development Goals Covered in UN Flagship Reports? A Contribution to the Study of the Science-Policy Interface on Education in the UN System. DESA Working Paper No. 146; NY, USA: Department of Economic & Social Affairs.
- Vyas, S.; Kumaranayake, L. (2006). *Constructing Socio-Economic Status Indices; how to use Principal Component Analysis*; London, UK: Oxford University Press in Association with The London School of Hygiene and Tropical Medicine. <https://doi.org/10.1093/heapol/czl029>.
- Wahba, S.; Ranarifidy, D. (2018). World Bank Blogs. Retrieved from *Re-awakening Kinshasa's Splendor Through Targeted Urban Interventions*. Available online: <https://blogs.worldbank.org/african/re-awakening-kinshasas-splendor-through-targeted-urban-interventions> (accessed on 2 October 2022).
- Walker, C., & Baxter, J. (2019). Method Sequence and Dominance in Mixed Methods Research: A Case Study of the Social Acceptance of Wind Energy Literature. *International Journal of Qualitative Methods*, 1–14. <https://doi.org/10.1017/>
- Wang, M., Li, M., Jin, B., Yao, L., & Ji, H. (2021a). Does Livelihood Capital Influence the Livelihood Strategy of Herdsmen? Evidence from Western China. *Land* 10,763. Retrieved from Doi: 10.3390/land10070763.
- Wang, W., Lan, Y., & Wang, X. (2021b). Impact of livelihood capital endowment on poverty alleviation of households under rural land consolidation. *Land Use Policy*.
- Weldegebriel, A., Assefa, E., Janusz, K., Tekalign, M., & Van Rompaey, A. (2021). Spatial Analysis of Intra-Urban Land Use Dynamics in Sub-Saharan Africa: The Case of Addis Ababa (Ethiopia). *Urban Science*, 5(3), 57. MDPI AG. Retrieved from <http://dx.doi.org/10.3390/urbansci5030057>.
- Weldeghebrael, E.H. (2022). The Framing of Inner-City Slum Redevelopment by an Aspiring Developmental State: The Case of Addis Ababa, Ethiopia. Available online: <https://doi.org/10.1016/j.cities.2020.102807> (accessed on 10 December 2022).
- Weimann, A., & Oni, T. (2019). A Systematised Review of the Health Impact of Urban Informal Settlements and Implications for Upgrading Interventions in South Africa, a Rapidly Urbanising Middle-Income Country. *Int J Environ Res Public Health* 16 (3608). Retrieved from doi: 10.3390/ijerph16193608. PMID: 31561522; PMCID: PMC6801583.
- Wendt, Susanne. (1997). *Slum and Squatter settlements in Dhaka: A study of Consolidation Process in Dhaka's low income settlement areas* [Doctoral Dissertation, Dhaka University]. Dhaka: Dhaka University, Department of Geography.
- Whelan, C.T, Maître, B. (2005). Economic vulnerability, multidimensional deprivation, and social cohesion in an enlarged European community. *Int. J. Comp. Sociol.* 46, 215–239. <https://doi.org/10.1177/0020715205058942>.
- Wikipedia. (2022). Multiple Deprivation Index. Available online: https://en.wikipedia.org/wiki/Multiple_deprivation_index (accessed on 17 September 2022).
- Wikipedia. (2022). Addis Merkato. Available online: https://en.wikipedia.org/wiki/Addis_Mercato#:~ (accessed on 2 November 2022).

- Wikipedia. (2023a, 3 March). Spearman's rank correlation coefficient. Retrieved from https://en.wikipedia.org/wiki/Spearman%27s_rank_correlation_coefficient.
- Wikipedia. (2023b, March 3). Pearson correlation coefficient. Retrieved from https://en.wikipedia.org/wiki/Pearson_correlation_coefficient.
- Wikipedia. (2023c, June 23). Addis Ababa. Retrieved from https://en.wikipedia.org/wiki/Addis_Ababa#
- Wilson, J.W. (1987). The truly disadvantaged. In *Theories of Urban Poverty and Implication for Public Housing Policy*. Curley, A.M., Ed.; Chicago, IL, USA: The University of Chicago Press.
- Wolde, M.; Sera, L.; Merra, T.M. (2020). The causal relationship between income inequality and economic growth in Ethiopia. *Cogent Econ. Finance*, 10 (1), 2087299. <https://doi.org/10.1080/23322039.2022.2087299>.
- Wong, S. (2001). Spatial Organization. Retrieved from International Encyclopedia of Social and Behavioral Science. Available online: <https://www.sciencedirect.com/topics/computer-science/spatial-organization> (accessed on 3 May 2019).
- Wong, C. (2006). *Indicators for Urban and Regional Planning: The Interplay of Policy and Methods*. New York, NY, USA: Routledge. <https://doi.org/10.4324/9780203642559>.
- World Bank Group. (2008). *Urban Poverty in Ethiopia: A Multifaceted and Spatial Perspective*. Washington, DC, USA: World Bank. Available online: <http://www.worldbank.org> (accessed on 16 January 2019).
- World Bank. (2015a). *Ethiopian Urbanization Review: Urban Institutions for Middle Income Ethiopia*. UN-Habitat, the State of Addis Ababa. Washington D. C: World Bank.
- World Bank. (2015b). *Ethiopia Poverty Assessment 2014: Poverty Global Practice African Region*. World Bank Group. Retrieved from <http://documents1.worldbank.org/curated/en/131011468247457565/pdf/AUS67440REVISE0essment0pub02020015.pdf>.
- World Bank. (2017). *Monitoring and Evaluating Ethiopia's Urban Productive Safety Net Project (UPSNP)*. Retrieved from <https://www.jobsanddevelopment.org/wp-content/uploads/2019/03/Ethiopia-MandE.pdf>
- World Bank. (2016). *Background Report on Urban Land Use Planning and Development for Land Governance Assessment Framework Implementation in Ethiopia: Panel 3 Gizachew Berhanu*. Addis Ababa: World Bank.
- World Bank (2022). *The World Bank in Social Protection*. Available online: <https://www.worldbank.org/en/topic/socialprotection/overview> (accessed on 20 October 2022).
- World Bank Group and Cities Alliance. (2015). *Ethiopian Urbanization Review*. Addis Ababa, Ethiopia: Urban Institutions for Middle-Income Ethiopia, World Bank.
- World Bank Group. (2020a). *Ethiopia Poverty Assessment: Poverty Rate Declines, Despite Challenges*. Available online: <https://www.worldbank.org/en/country/ethiopia/publication/ethiopia-poverty-assessment-poverty-rate-declines-despite-challenges> (accessed on 5 October 2022).
- World Bank Group. (2020b). *Ethiopia Poverty Assessment. Harnessing Continued Growth for Accelerated Poverty Reduction*; Washington, DC, USA: World Bank.
- World Bank Group. (2021). *Towards an Inclusive and Empowered Ethiopia: Improving Social Safety Nets to Reduce Urban Poverty*. 14 January 2021. Available online: <https://www.worldbank.org/en/results/2021/01/14/towards-an-inclusive-and-empowered-ethiopia-improving-social-safety-nets-to-reduce-urban-poverty> (accessed on 22 March 2022).
- WorldPop. (2010). (www.worldpop.org - School of Geography and Environmental Science, University of Southampton). 2013. Ethiopia 100m Population. Alpha version 2010 estimates of numbers of people per grid square, with national totals adjusted to match UN population division estimates (<http://esa.un.org/wpp/>). DOI: 10.5258/SOTON/WP00087.
- World Highways. (2018). *Ethiopian capital Addis Ababa's road development*. Retrieved from <https://www.worldhighways.com/wh10/news/ethiopian-capital-addis-ababas-road-development#>.
- WorldPop. (2020). (www.worldpop.org - School of Geography and Environmental Science, University of Southampton; Department of Geography and Geosciences, University of Louisville; Departement de Geographie, Universite de Namur) and Center for International Earth Science Information Network (CIESIN), Columbia University (2018). *Global High Resolution Population Denominators Project - Funded by The Bill and Melinda Gates Foundation (OPP1134076)*. <https://dx.doi.org/10.5258/SOTON/WP00649>.
- WorldPop-University of Southampton. (2023, February 3). *WorldPop gridded Population estimate dataset and tools. How are they different and which should I use*. Retrieved from <http://www.worldpop.org/methods/population>
- Yamane, T. (1967). *Statistics, An Introductory Analysis (2nd Ed)*. New York: Harper and Row.
- Yeshitela, K. (n.d). *Report 1: Green Area Typologies and Mapping of Green Structure in Addis Ababa and Dares salaam*. EiABC, University of Copenhagen, Danida.
- Yirga, B. (2021). *The livelihood of urban poor households: A sustainable livelihood approach in urbanizing Ethiopia. The case of Gondar City, Amhara National State*. *Poverty and Public Policy*. Retrieved from <https://doi.org/10.1002/pop4.306>.
- Yodmani, S. (2001). *Disaster Risk Management and Vulnerability Reduction: Protecting the Poor: Social Protection Workshop 6: Protecting Communities, Social*

- Fund and Disaster Management. In P. Damas, & R. Israt, *Vulnerability and Poverty: What are the causes and how they are related*
https://www.zef.de/fileadmin/downloads/forum/docprog/Termpapers/2004_3a_Philip_Rayan.pdf.
- Yuan, Y.; Fulong, W. (2014). The development of the index of multiple deprivations from a small area population census in the city of Guangzhou. *Habitat Int.*, 41, 142–149. <https://doi.org/10.1016/j.habitatint.2013.07.010>.
- Zafu, A., & Peter, N. (2014). Older Slum in Addis Ababa, Ethiopia: How do they work? *ARCHCAIRO 2014: Responsive Urbanism in Informal Areas*, 6th International Conference (pp. 514–525). Perth, Australia: Curtin University.
- Zein, T., Hartfiel, P., & Berisso, Z. A. (2012). Addis Ababa: The Road Map Progress to Securing Property Rights with Real Property registration System. *Annual- World Bank Conference on Land and Poverty: The World-Bank*, Washington DC, April 23-26, 2012 (pp. 1-52). Washington DC: The World Bank.
- Zewdie, M., & Worku, H. & Bantider, A. (2021). Inner City Urban Renewal: Assessing the Sustainability and Implications for Urban Landscape Change of Addis Ababa. *Journal of Housing and the Built Environment* (36), 1249-1275. <https://doi.org/10.1007/s10901-020-09797-7>.

Annex-1 Questionnaire for Addis ketema sub-city Wereda 07 (inner city slum)

SECTION 1: AREA IDENTIFICATION				Household/Building Unique code		Sub city	Wereda	Kebele	House. No	X Coordinate	Y Coordinate
Full Name of Householder				No of Member		Have you ever been in AA before you came here?		If Yes, Specify the Sub city in AA you were before?			
Male <input type="checkbox"/>		Female <input type="checkbox"/>		Male <input type="checkbox"/>		Female <input type="checkbox"/>		<input type="checkbox"/> Yes <input type="checkbox"/> No			

SECTION-2: HOUSEHOLD BASIC CHARACTERISTICS											
Household Head Sex 1 <input type="checkbox"/> M <input type="checkbox"/> F		Household Head Age 2		HH Length Residence 3		HH NO. MALE 4		NO. FEMALE 4		Marital Status 5	
										<input type="checkbox"/> Never married <input type="checkbox"/> Married <input type="checkbox"/> Divorced <input type="checkbox"/> Widowed <input type="checkbox"/> Separated <input type="checkbox"/> Cohabiting/living together	
The highest grade completed (for HH head) 10		Please enter the code as per the instruction manual		The Highest Grade Completed other family members 11		Employment Status 12		Religion 6		Ethnicity 7	
				Pre school 1-4 primary 5-8 Primary 9-10 High school		Productive Work for last 12 month <input type="checkbox"/> Government (Formal) <input type="checkbox"/> Private Org. (Formal) <input type="checkbox"/> Self-Employed (Formal) <input type="checkbox"/> Self-Employed (Informal) <input type="checkbox"/> Construction Worker (Unskilled) <input type="checkbox"/> Construction Worker (Skilled >= TVET) <input type="checkbox"/> Unpaid Family Worker <input type="checkbox"/> Employer <input type="checkbox"/> Others specify		<input type="checkbox"/> Orthodox <input type="checkbox"/> Protestant <input type="checkbox"/> Catholic <input type="checkbox"/> Muslim/Islam <input type="checkbox"/> Traditionalist <input type="checkbox"/> Others		Please Enter the code for the ethnic group from the list shown in the instruction manual	
Tenure Status 18		Perception of Tenure 19		HH head involve in Community Based org. 20		Number of Room for Household family 21		Number of Rented room 22		PLACE OF BIRTH (HH) 13	
<input type="checkbox"/> Kebele Tenant <input type="checkbox"/> Municipal Tenant <input type="checkbox"/> Owner right (Tax receipt) <input type="checkbox"/> Owner right (Title deed) <input type="checkbox"/> Sub Tenant (Tenant) <input type="checkbox"/> Tenant from Private owner right <input type="checkbox"/> Informal House Owner (Farm/public land) <input type="checkbox"/> Rented from Informal House Owner (informal)		1. Very Insecure 2. Insecure 3. Do not know 4. Secure 5. Very Secure		<input type="checkbox"/> Edir and /or Ekub <input type="checkbox"/> Other Association <input type="checkbox"/> No involvement		Not Including Kitchen and Toilet		<input type="checkbox"/> Addis Ababa <input type="checkbox"/> Other Places		Age of HH family 14	
Transport (Work to Home in Min or hrs) 25		HH Income (monthly birr) 15		Perception of HH on Morbidity 23		Frequency Pattern of the Family		Do you have Kitchen 26		Household Income (monthly birr) 15	
		<input type="checkbox"/> 0-14 <input type="checkbox"/> 15-64 <input type="checkbox"/> 65+		<input type="checkbox"/> Very High <input type="checkbox"/> High <input type="checkbox"/> Medium <input type="checkbox"/> Low <input type="checkbox"/> Very low		<input type="checkbox"/> Yes <input type="checkbox"/> No		or monthly paid: Gov. private Org., NGO otherwise based on expenditure		HH Head Neighborhood Crime Perception 24	
										<input type="checkbox"/> Very High Crime <input type="checkbox"/> High Crime <input type="checkbox"/> Medium Crime <input type="checkbox"/> Low Crime <input type="checkbox"/> Very Low Crime	

HOUSE FUNCTION (HH)				SECTION-3: PARCEL AND BUILDING CHARACTERISTICS				Major Material (Wall) 8				Major Material (Roof) 10							
<input type="checkbox"/> Residential (RES) 1 <input type="checkbox"/> RES + Commercial <input type="checkbox"/> RES + Manufacturing <input type="checkbox"/> RES + Services				Major Material (Floor) 4				How many years' ago this housing was built 7				<input type="checkbox"/> Wood & Mud <input type="checkbox"/> Wood and Thatch/Wood only <input type="checkbox"/> Stone & Mud <input type="checkbox"/> Corrugated Iron Sheet <input type="checkbox"/> Stone & Cement <input type="checkbox"/> Plastered/unplaster Hollow Block <input type="checkbox"/> Bricks <input type="checkbox"/> Reed/Bamboo <input type="checkbox"/> Others				<input type="checkbox"/> (CIS) Corru. Iron Sheet <input type="checkbox"/> Plastic / Shera <input type="checkbox"/> Metal Sheet <input type="checkbox"/> Corrugated & Mica <input type="checkbox"/> Thatch <input type="checkbox"/> Clay tile <input type="checkbox"/> Asbestos <input type="checkbox"/> Ega Sheet <input type="checkbox"/> Decra <input type="checkbox"/> others			
Building Condition 2				Cond 5				Cond 9				Cond 11							
<input type="checkbox"/> 1) Good <input type="checkbox"/> 2) Minor Repair <input type="checkbox"/> 3) Major Repair <input type="checkbox"/> 4) Replacement				Does the House/Main House have Foundation 6				Housing of Household Location in Relation to Hazard 14				Does the House Comply with Building Regulation & Standard 15							
<input type="checkbox"/> attached to other House <input type="checkbox"/> Detached				<input type="checkbox"/> Yes <input type="checkbox"/> No				<input type="checkbox"/> Dangerous Right Way (Rail, Highway, Sewer lines) < 20 m <input type="checkbox"/> Near Garbage Mountain/solid waste <input type="checkbox"/> Near Flood Plain <input type="checkbox"/> Steep Slopes <input type="checkbox"/> Near polluted river				<input type="checkbox"/> Near (100m) toxic Industrial Waste <input type="checkbox"/> High Tension Line (< 50 m) <input type="checkbox"/> Near Toilet/Excrete <input type="checkbox"/> No Hazard in neighborhood <input type="checkbox"/> Others specify:				<input type="checkbox"/> Yes <input type="checkbox"/> No			
Bld. Floor Area(m2) 16		No. Floor 16		Major Material (Ceiling) 12				Cond 13											
				<input type="checkbox"/> None <input type="checkbox"/> Fabrics <input type="checkbox"/> Bamboo/Reed <input type="checkbox"/> Chip Wood/Hardboard <input type="checkbox"/> Wood Planks				<input type="checkbox"/> Parquet/Polished Wood <input type="checkbox"/> Concrete/Cement <input type="checkbox"/> Polythene Sheet/Madaberia <input type="checkbox"/> Others											

SECTION-4: SERVICES AND INFRASTRUCTURE

1 Main Drinking Water Source of the housing unit of HH <input type="checkbox"/> Piped Water Connection to house/plot <input type="checkbox"/> Vendor Provided Water <input type="checkbox"/> Improved Protected Spring <input type="checkbox"/> Improved Hand Dug Well/Borehole <input type="checkbox"/> River/Lake/Pond <input type="checkbox"/> Tanker Truck		2 Main Sanitation service for housing unit of HH <input type="checkbox"/> Connection to Public Sewer or Septic Tank <input type="checkbox"/> Ventilated Improved Pit Latrine <input type="checkbox"/> Unventilated Pit Latrine		3 Dispose Solid Waste by Housing Unit of HH <input type="checkbox"/> Collected by Municipality (Public Dump) <input type="checkbox"/> Collected by Private Establishments/Individuals <input type="checkbox"/> Dumped in Street/Open Space <input type="checkbox"/> Dumped in River <input type="checkbox"/> Burned/Buried Solid Waste <input type="checkbox"/> Other		4 Frequency of Water Availability <input type="checkbox"/> Daily <input type="checkbox"/> 3-4 days in a Week <input type="checkbox"/> 1-2 days in a week <input type="checkbox"/> > 7 days not available Duration per day(hour):	
5 The type of kitchen does the housing unit have? <input type="checkbox"/> No kitchen <input type="checkbox"/> Modern kitchen <input type="checkbox"/> Traditional Kitchen in the house <input type="checkbox"/> Traditional Kitchen outside housing unit		Kitchen type: <input type="checkbox"/> Common <input type="checkbox"/> Own		6 Does the household share toilet with other households <input type="checkbox"/> yes <input type="checkbox"/> No If yes, specify number of households sharing toilet:		7 Does the household share Piped Water, Public stand Pipe or Spring with other households <input type="checkbox"/> yes <input type="checkbox"/> No If yes, specify number of households sharing water facility:	
				8 For those HH without private Water Meter, specify the price of water in birr per Jerri can(20 liter)		9 Specify # of Jerri can used Per day on average	

SECTION-5: REGULATORY AND THEORETICAL RELATED REVIEW

1 How do you Construct the House? <input type="checkbox"/> By my own family /Self-Construction <input type="checkbox"/> By my own family and partly by hiring skilled worker <input type="checkbox"/> By Building Contractor <input type="checkbox"/> Hiring Skilled Worker <input type="checkbox"/> Tenant/Renter		2 Land Acquisition Method <input type="checkbox"/> Permit Private Right <input type="checkbox"/> Lease Right <input type="checkbox"/> Kebele(Permit) <input type="checkbox"/> Municipality(Permit) <input type="checkbox"/> Sale(Permit/Lease) <input type="checkbox"/> Tenancy agriculture land <input type="checkbox"/> Buying Agriculture Land from farmer		<input type="checkbox"/> Donation <input type="checkbox"/> Inheritance (permit /Lease) <input type="checkbox"/> Informal Sale Transact. <input type="checkbox"/> Gift(permit/Lease) <input type="checkbox"/> Construct on vacant land <input type="checkbox"/> Other specify		3 How regular is your income? <input type="checkbox"/> Same income every week/month <input type="checkbox"/> Similar mostly every week or Month <input type="checkbox"/> Income is different every week/month <input type="checkbox"/> Other specify		4 How is your perception on the improvement status of services and Infrastructure on your neighborhood from previous status? <input type="checkbox"/> Very high Improvement <input type="checkbox"/> High improvement <input type="checkbox"/> To some extent Improvement <input type="checkbox"/> High Deteriorated <input type="checkbox"/> Very High Deteriorated		5 Have you ever participated in LDP Plan preparation in your neighborhood <input type="checkbox"/> Not at All <input type="checkbox"/> Once <input type="checkbox"/> Twice <input type="checkbox"/> Twice and More		6 How is your perception on the improvement status of existing housing condition <input type="checkbox"/> Very high Improved <input type="checkbox"/> High improved <input type="checkbox"/> To Some Extent Improved <input type="checkbox"/> High Deteriorated <input type="checkbox"/> Very High Deteriorated	
7 What is your best option for securing affordable modern housing that meet the standard?(inner slum) <input type="checkbox"/> Incremental (5-15 years) Housing upgrading on existing to meet the standard <input type="checkbox"/> Upgrading within 2-5 years on existing to meet the standard <input type="checkbox"/> Better maintain with the existing materials of housing		<input type="checkbox"/> On site accommodation through condominium housing <input type="checkbox"/> Condominium housing elsewhere in Addis Ababa <input type="checkbox"/> similar plot provision elsewhere <input type="checkbox"/> Other options		8 Do you believe that the current Planning Regulation has contributed for improvement of services (Sanitation, Water, Waste disposal) in your neighborhood? <input type="checkbox"/> Very high <input type="checkbox"/> High <input type="checkbox"/> Medium <input type="checkbox"/> Low <input type="checkbox"/> VeryLow		9 Do you believe that Planning Regulation has contributed for improvement of Infrastructure (Road, Drainage, etc.) in your Neighborhood? <input type="checkbox"/> Very high <input type="checkbox"/> High <input type="checkbox"/> Medium <input type="checkbox"/> Low <input type="checkbox"/> VeryLow		10 Where do you wish to Construct House in the future? <input type="checkbox"/> Upgrade Existing Housing (Owner) <input type="checkbox"/> Construct House on Periphery by buying from Farmers/seller <input type="checkbox"/> Waiting for Condo/40-60 lottery <input type="checkbox"/> Construct house on land right provided by government <input type="checkbox"/> Other Options specify:		11 How Do you want to use your parcel? <input type="checkbox"/> Residential only <input type="checkbox"/> Residential + Manufacturing <input type="checkbox"/> Residential + Commerce <input type="checkbox"/> Residential + Service <input type="checkbox"/> Residence + Agriculture. <input type="checkbox"/> Other Specify		12 How long it will take to obtain formal housing or land right according to your impression? <input type="checkbox"/> < 3 years <input type="checkbox"/> 3-6 years <input type="checkbox"/> 7-10 Years <input type="checkbox"/> 10-15 years <input type="checkbox"/> > 15 years	
13 Do you hope that yours/your family living standard will improve in the future in existing neighborhood? <input type="checkbox"/> Very High <input type="checkbox"/> High <input type="checkbox"/> Medium <input type="checkbox"/> Low <input type="checkbox"/> Very Low		14 Which vulnerabilities are the most significant one affecting your families? <input type="checkbox"/> Lack of Shelter <input type="checkbox"/> Flood Hazard <input type="checkbox"/> Poor sanitation <input type="checkbox"/> Poor Waste Disposal <input type="checkbox"/> Poor Water Quality <input type="checkbox"/> Cost of Health Medicine <input type="checkbox"/> Cost of Water price <input type="checkbox"/> Crime prevalence <input type="checkbox"/> Cost of Transport <input type="checkbox"/> Cost of electricity/energy <input type="checkbox"/> Lack of Food <input type="checkbox"/> Others specify:		15 What is the affordable building permit Standard for you? <input type="checkbox"/> Existing Modern Standard for New Construction <input type="checkbox"/> Lowering Existing Standard for New Construction <input type="checkbox"/> Upgrade Existing House with Modern Material <input type="checkbox"/> Upgrade Existing House with existing house material <input type="checkbox"/> Condominium house in existing neighborhood <input type="checkbox"/> Condominium house Elsewhere <input type="checkbox"/> 40-60 modern house in existing neighborhood <input type="checkbox"/> 40-60 modern house elsewhere <input type="checkbox"/> Others Specify:		16 How do you rate your participation in election of Kebele /Sub city authoritative bodies <input type="checkbox"/> Very high <input type="checkbox"/> High <input type="checkbox"/> Medium <input type="checkbox"/> Low <input type="checkbox"/> Very Low		17 What Possible income generating activity you have/want to have from your housing/holding? <input type="checkbox"/> Construct More room for House rent <input type="checkbox"/> Used for Residence Activity only <input type="checkbox"/> Home Based Business <input type="checkbox"/> Vegetable growing <input type="checkbox"/> Poultry <input type="checkbox"/> Other Specify:		18 Do you have ever had access to credit or Micro Finance by Government /NGO's for Housing Improvement? <input type="checkbox"/> Yes <input type="checkbox"/> No			

Annex-2 Questionnaire Kolfe Keranyo Wereda 03 peri urban Informal settlement

Full Name of Householder				No of Co-Dwellers		No of Renter		Sub city	Wereda	Kebele	House. No	X Coordinate	Y Coordinate
Male		Female		Male		Female							

SECTION-2: HOUSEHOLD BASIC CHARACTERISTICS

Household Head Sex 1 <input type="checkbox"/> M <input type="checkbox"/> F	Household Head Age 2	HH Length Residence 3	HH NO. MALE 4 <input type="text"/>	HH NO. FEMALE 4 <input type="text"/>
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Marital Status 5 <input type="checkbox"/> Never married <input type="checkbox"/> Married <input type="checkbox"/> Divorced <input type="checkbox"/> Widowed <input type="checkbox"/> Separated <input type="checkbox"/> Cohabiting/living together	Religion 6 <input type="checkbox"/> Orthodox <input type="checkbox"/> Protestant <input type="checkbox"/> Catholic <input type="checkbox"/> Muslim/Islam <input type="checkbox"/> Traditionalist <input type="checkbox"/> Others	Ethnicity 7 <input type="checkbox"/> <i>Please Enter the code for the ethnic group from the list shown in the instruction manual</i>
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Tenure Status 18 <input type="checkbox"/> Kebele Tenant <input type="checkbox"/> Municipal Tenant <input type="checkbox"/> Owner right(Tax receipt) <input type="checkbox"/> Owner right(Title deed) <input type="checkbox"/> Sub Tenant(Tenant) <input type="checkbox"/> Tenant from Private owner right <input type="checkbox"/> Informal House Owner(Farm/public land) <input type="checkbox"/> Rented from Informal House Owner (informal)	Perception of Tenure 19 1. Very Insecure 2. Insecure 3. Do not know 4. Secure 5. Very Secure	Number of Room for Household family 21 <input type="text"/> <small>Not Including Kitchen and Toilet</small>
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HH head-involve in Community Based org. 20 <input type="checkbox"/> Edir and /or Ekub <input type="checkbox"/> Other Association <input type="checkbox"/> No involvement	Number of Rented room 22 <input type="text"/>
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No. of Unemployed Male in HH 8 18-30 <input type="text"/> 30-65 <input type="text"/>	No. of Unemployed Female in HH 9 18-30 <input type="text"/> 30-65 <input type="text"/>	The highest grade completed(for HH head) 10 <input type="checkbox"/> <i>Please enter the code as per the instruction manual</i>	The Highest Grade Completed other family members 11 Pre school <input type="text"/> 1-4 primary <input type="text"/> 5-8 Primary <input type="text"/> 9-10 High school <input type="text"/> 11-12 <input type="text"/> Diploma <input type="text"/> BA <input type="text"/> MA/MSC & > <input type="text"/>
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Employment Status(Productive Work in last 12 months) 12 <input type="checkbox"/> Government Formal <input type="checkbox"/> Private Org. Formal <input type="checkbox"/> Self Employed Formal <input type="checkbox"/> Self Employed Informal <input type="checkbox"/> Construct. Worker(Unskilled) <input type="checkbox"/> Construct. Worker(Skilled TVET) <input type="checkbox"/> Domestic Worker <small>Home maker</small> <input type="checkbox"/> Casual Farm Worker <input type="checkbox"/> Pensioner <input type="checkbox"/> No Employment <input type="checkbox"/> Others Specify:	PLACE OF BIRTH(HH) 13 <input type="checkbox"/> Addis Ababa <input type="checkbox"/> Other Places	Age of HH family 14 0-14 <input type="text"/> 15-64 <input type="text"/> 65+ <input type="text"/>	Household Income (monthly birr) 15 <input type="checkbox"/> <i>For monthly paid: Gov. Private Org., NGO otherwise based on expenditure</i>	Expenditure 16 <table style="width: 100%;"><tr><th>Expenditure</th><th>Amount(birr) Per month</th></tr><tr><td>Food</td><td></td></tr><tr><td>Clothing</td><td></td></tr><tr><td>Water</td><td></td></tr><tr><td>Housing</td><td></td></tr><tr><td>Energy(light, cooking)</td><td></td></tr><tr><td>Transport</td><td></td></tr><tr><td>House Rent</td><td></td></tr><tr><td>Traditional saving</td><td></td></tr><tr><td>Bank saving</td><td></td></tr><tr><td>Health cost</td><td></td></tr><tr><td>Education</td><td></td></tr><tr><td>Miscellaneous (leisure)</td><td></td></tr><tr><td>Total Expenditure</td><td></td></tr></table> <small>For Clothing, Bank saving collect data in year divided by 12</small>	Expenditure	Amount(birr) Per month	Food		Clothing		Water		Housing		Energy(light, cooking)		Transport		House Rent		Traditional saving		Bank saving		Health cost		Education		Miscellaneous (leisure)		Total Expenditure	
Expenditure	Amount(birr) Per month																															
Food																																
Clothing																																
Water																																
Housing																																
Energy(light, cooking)																																
Transport																																
House Rent																																
Traditional saving																																
Bank saving																																
Health cost																																
Education																																
Miscellaneous (leisure)																																
Total Expenditure																																

Perception of HH on Morbidity 23 <input type="checkbox"/> Very High <input type="checkbox"/> High <input type="checkbox"/> Medium <input type="checkbox"/> Low <input type="checkbox"/> Very low	HH Head Neighborhood Crime Perception 24 <input type="checkbox"/> Very High Crime <input type="checkbox"/> High Crime <input type="checkbox"/> Medium Crime <input type="checkbox"/> Low Crime <input type="checkbox"/> Very Low Crime	Transport (Work to Home in Min or hrs) 25 <input type="text"/>
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Do you have Kitchen 26 <input type="checkbox"/> Yes <input type="checkbox"/> No	Ability to pay for Housing per Month (in Birr) 17 <input type="text"/>
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SECTION-3: PARCEL AND BUILDING CHARACTERISTICS

HOUSE FUNCTION(HH) 1 <input type="checkbox"/> Residential(RES) <input type="checkbox"/> RES+ Commercial <input type="checkbox"/> RES+ Manufacturing <input type="checkbox"/> RES+ Services	Major Material(Floor) 4 <input type="checkbox"/> Mud <input type="checkbox"/> Bamboo/Reed <input type="checkbox"/> Wood Planks <input type="checkbox"/> Parquet/polished Wood <input type="checkbox"/> Plastic Tile Cond 5	<input type="checkbox"/> Cement <input type="checkbox"/> Screed/Cement <input type="checkbox"/> Screed Not Applied <input type="checkbox"/> Cement Tile/Brick tile <input type="checkbox"/> Ceramic/ Marble Tile <input type="checkbox"/> Other
---	--	--

Building Condition 2 <input type="checkbox"/> 1) Good <input type="checkbox"/> 2) Minor Repair <input type="checkbox"/> 3) Major Repair <input type="checkbox"/> 4) Replacement	Does the House/Main House have Foundation 6 <input type="checkbox"/> Yes <input type="checkbox"/> No	How many years ago this housing was built 7 <input type="text"/>
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Is the house attached? 3 <input type="checkbox"/> attached to other House <input type="checkbox"/> Detached	Major Material(Wall) 8 <input type="checkbox"/> Wood & Mud <input type="checkbox"/> Wood and Thatch/Wood only <input type="checkbox"/> Stone & Mud <input type="checkbox"/> Corrugated Iron Sheet Cond 9	<input type="checkbox"/> Stone & Cement <input type="checkbox"/> Plastered/unplaster Hollow Block <input type="checkbox"/> Bricks <input type="checkbox"/> Reed/Bamboo <input type="checkbox"/> Others
--	---	--

Major Material(Roof) 10 <input type="checkbox"/> (CIS)Corru. Iron Sheet <input type="checkbox"/> Plastic / Shera <input type="checkbox"/> Metal Sheet <input type="checkbox"/> Corrugated & Mica <input type="checkbox"/> Thatch Cond 11	<input type="checkbox"/> Clay tile <input type="checkbox"/> Asbestos <input type="checkbox"/> Ega Sheet <input type="checkbox"/> Decra <input type="checkbox"/> others
--	--

Housing of Household Location in Relation to Hazard 14 <input type="checkbox"/> Sewer Lines <input type="checkbox"/> Near Garbage Mountain/Solid Waste <input type="checkbox"/> Near Flood Plain <input type="checkbox"/> On Steep Slopes <input type="checkbox"/> Near Polluted River	<input type="checkbox"/> Near(100m) Toxic Industrial Waste <input type="checkbox"/> High Tension Line (< 50 m) <input type="checkbox"/> Near Toilet/Excreta <input type="checkbox"/> No Hazard Neighborhood <input type="checkbox"/> Others specify:
--	--

Does the House Comply with Building Regulation & Standard 15 <input type="checkbox"/> Yes <input type="checkbox"/> No	Bid. Floor Area(m2) 16 <input type="text"/>	No. Floor 16 <input type="text"/>
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SECTION-4: SERVICES AND INFRASTRUCTURE

Main Drinking Water Source of the housing unit of HH 1 <input type="checkbox"/> Piped Water Connection to house/plot <input type="checkbox"/> Vendor Provided Water <input type="checkbox"/> Improved Protected Spring <input type="checkbox"/> Improved Hand Dug Well/Borehole <input type="checkbox"/> River/Lake/Pond	<input type="checkbox"/> Public Stand Pipe Serving <= 5 household <input type="checkbox"/> Public Stand Pipe serving > 5 household <input type="checkbox"/> Unprotected Spring <input type="checkbox"/> Unprotected hand Dug Well/Borehole <input type="checkbox"/> Collect Rain Water
--	--

Main Sanitation service for housing unit of HH 2 <input type="checkbox"/> Connection to Public Sewer or Septic Tank <input type="checkbox"/> Ventilated Improved Pit Latrine <input type="checkbox"/> Unventilated Pit Latrine	<input type="checkbox"/> Bucket or Service Latrine ,excreta removed manually <input type="checkbox"/> Pour Flush Latrine <input type="checkbox"/> Dispose Excreta Open Field <input type="checkbox"/> Flying Toilet/Plastic Bag
--	--

Dispose Solid Waste by Housing Unit of HH 3 <input type="checkbox"/> Collected by Municipality (Public Dump) <input type="checkbox"/> Collected by Private Establishments/Individuals <input type="checkbox"/> Dumped in Street/Open Space <input type="checkbox"/> Dumped in River <input type="checkbox"/> Burned/Buried Solid Waste <input type="checkbox"/> Other	Frequency of Water Availability 4 <input type="checkbox"/> Daily <input type="checkbox"/> 3-4 days in a Week <input type="checkbox"/> 1-2 days in a week <input type="checkbox"/> > 7 days not available Duration per day(hour):
--	---

The type of kitchen does the housing unit have?

No kitchen
 Modern kitchen
 Traditional Kitchen in the house
 Traditional Kitchen outside housing unit

5

Water Treatment use 6

None
 Boiled
 Chlorine/Other Chemicals
 Strain Through Cloth
 Water Filter Use
 Solar Disinfection
 Let it Stand and Settle
 Others Specify:

Does the household share toilet with other households 7	Does the household share Piped Water, Public stand Pipe or Spring with other households 8
<input type="checkbox"/> yes <input type="checkbox"/> No	<input type="checkbox"/> yes <input type="checkbox"/> No
If yes, specify number of households sharing toilet:	If yes, specify number of households sharing water facility:

For those HH without private Water Meter, specify the price of water in birr per Jerri can(20 liter) 9	Specify # of Jerri can used Per day on average 10
--	---

Kitchen type:
 Common
 Own

11

SECTION-5: REGULATORY AND THEORETICAL RELATED REVIEW

How do you Construct the House? 1

By my own family /Self-Construction
 By my own family and partly by hiring skilled worker
 By Building Contractor
 Hiring Skilled Worker
 Tenant/Renter

Land Acquisition Methods 2

<input type="checkbox"/> Buy Informal Sub-Dividers	<input type="checkbox"/> Lease Right
<input type="checkbox"/> Buy Farmer	<input type="checkbox"/> Construct on Vacant land
<input type="checkbox"/> Buy Settlers	<input type="checkbox"/> Rented from Informal holders
<input type="checkbox"/> Peasant Author. Permission	<input type="checkbox"/> Rented from Farmer
<input type="checkbox"/> kebele Right Permit	<input type="checkbox"/> Inheritance(Permit/lease)
<input type="checkbox"/> Private Permit Right	<input type="checkbox"/> Other Specify:

How regular is your income? 3

Same income every week/month
 Similar mostly every week or Month
 Income is different every week/month
 Other specify

How is your perception on the improvement status of services and Infrastructure on your neighborhood from previous status? 4

<input type="checkbox"/> Very high Improvement	<input type="checkbox"/> To some extent Improvement
<input type="checkbox"/> High improvement	<input type="checkbox"/> High Deteriorated
	<input type="checkbox"/> Very High Deteriorated

What is your best expectation from Urban planning? 5

To be regularized/Title deed in existing area
 Low Cost house in existing
 Low Cost house elsewhere
 Provision of Service and infras.
 Others specify:

How is your perception on the improvement status of existing housing condition 6

<input type="checkbox"/> Very high Improved	<input type="checkbox"/> High Deteriorated
<input type="checkbox"/> High improved	<input type="checkbox"/> Very High Deteriorated
<input type="checkbox"/> To Some Extent Improved	

What is your best option for securing affordable modern housing that meet the standard?(inner slum) 7

<input type="checkbox"/> Incremental (5-15 years) Housing upgrading on existing to meet the standard? <input type="checkbox"/> Upgrading within 2-5 years on existing to meet the standard <input type="checkbox"/> Better maintain with the existing materials of housing	<input type="checkbox"/> On site accommodation through condominium housing <input type="checkbox"/> Condominium housing elsewhere in Addis Ababa <input type="checkbox"/> similar plot provision elsewhere <input type="checkbox"/> Other options
--	--

Do you believe that services are improved (Sanitation, Water and Waste Disposal) in your neighborhood? 8

Very High
 High
 Medium
 Low
 Very Low

Do you believe that Infrastructure are improved (Road, Drainage, walkways) in your neighborhood? 9

Very High
 High
 Medium
 Low
 Very Low

Where do you wish to Construct House in the future? 10

Upgrade Existing Housing (Owner)
 Construct House on Periphery by buying from Farmers/seller
 Waiting for Condo/40-60 lottery
 Construct house on land right provided by government
 Other Options specify:

How Do you want to use your parcel? 11

<input type="checkbox"/> Residential only	<input type="checkbox"/> Residential + Commerce
<input type="checkbox"/> Residential + Manufacturing	<input type="checkbox"/> Residential + Service
	<input type="checkbox"/> Residence + Agriculture.
	<input type="checkbox"/> Other Specify

Do you hope that yours/your family living standard will improve in the future in existing neighborhood? 13

Very High Low
 High Very Low
 Medium

Which vulnerabilities are the most significant one affecting your families? 14

<input type="checkbox"/> Lack of Shelter	<input type="checkbox"/> Cost of Water price
<input type="checkbox"/> Flood Hazard	<input type="checkbox"/> Crime prevalence
<input type="checkbox"/> Poor sanitation	<input type="checkbox"/> Cost of Transport
<input type="checkbox"/> Poor Waste Disposal	<input type="checkbox"/> Cost of electricity/energy
<input type="checkbox"/> Poor Water Quality	<input type="checkbox"/> Lack of Food
<input type="checkbox"/> Cost of Health Medicine	<input type="checkbox"/> Others specify:

How long it will take to obtain formal housing or land right according to your impression? 12

< 3 years 10-15 years
 3-6 years > 15 years
 7-10 Years

What is the affordable building permit Standard for you? 15

Existing Modern Standard for New Construction
 Lowering Existing Standard for New Construction
 Upgrade Existing House with Modern Material
 Upgrade Existing House with existing house material
 Condominium house in existing neighborhood
 Condominium house Elsewhere
 40-60 modern house in existing neighborhood
 40-60 modern house elsewhere
 Others Specify:

How do you rate your participation in election of Kebele /Sub city authoritative bodies 16

Very high
 High
 Medium
 Low
 Very Low

What Possible income generating activity you have/want to have from your housing/holding? 17

<input type="checkbox"/> Construct More room for House rent	<input type="checkbox"/> Vegetable growing
<input type="checkbox"/> Used for Residence Activity only	<input type="checkbox"/> Poultry
<input type="checkbox"/> Home Based Business	<input type="checkbox"/> Other Specify:

How much you bought your plot in birr?

How is the size of your plot in m2 18

Annex-3 open ended questionnaires

3.1) Questionnaire for Addis Ketema Sub-city (kifle ketema) Wereda 07

Mandatory conditions:

- Interview with pertinent officials and collecting documents.
- The name, position, organization and the address of the key informant shall be stated

Other pertinent documents:

- If necessary, other supporting documents need to be collected in relation to the interview

Questionnaires:

Part 1: Questionnaire for sub-city

1. Which formal institutions of the sub city are working on poverty alleviations?

የትኛው የክፍለ ከተማውና የመንግስት ተቋማት በድህነት ቅነሣ ላይ እንደሚሰሩ ቢያብራሩልን?(ለጥቃቅንና አነስተኛ ተቋማት ቢሮ፣ ለሴቶች ጉዳይ ቢሮ፣ ለአካባቢ ጥበቃ ቢሮ፣ የህብረተሰብ ተሳትፎ ማስተባበሪያ ቢሮ)

2. Which local institutions (Community Based organizations such as Edir and Ekub, Women Associations and other local assistance associations) of the sub/city are working on poverty alleviations and environment protection? Can you elaborate what has been achieved so far by the specific sector of the community local organizations on poverty alleviation and environment protection activities of the sub-city?

የትኛው በክፍለ ከተማው ያለ የህብረተሰቡ ተቋም (እድር፣ እቁብ ፤ የሴቶች ማህበር ፤ የመረዳጃ ማህበር --ወዘተ) በድህነት ቅነሣ እና በአካባቢ ጥበቃ ላይ ይሠራል? እስካሁን እነዚህ የህብረተሰቡ ተቋማት በክፍለ ከተማው ድህነት ቅነሳ እና በአካባቢ ጥበቃ ስራ ላይ ያከናወኗቸውን ተግባራትና ያመጡትን ለውጦች በዝርዝር ሊያብራሩልን ይችላሉ?

3. Is there an option to provide Legal tenure right for dwellers of peri-urban informal settlements and those who constructed house illegally? What has been done so far for those houses constructed without legal municipal right? Is there a plan to demolish the currently existed illegal houses or demolishing them? If there is demolition practice, what were the consequences of demolishing houses on livelihood of the victim households?

በህገወጥ ቤት የገነቡ ነዋሪዎችን፤ በመጠለያ የሚኖሩትን ሕጋዊ የመሬት ይዘታ ማረጋገጫ ለመስጠት እቅድ አለ ? ከዚህ በፊት በህገወጥ መንገድ የገነቡት ላይ ምን ዕርምጃ እንደተወሰደ ሊያብራሩልን ? አሁንስ በህገወጥ መንገድ ገንብተው ያሉ ህብረተሰቦችን ህጋዊ የማድረግ ነው ወይስ የማፍረስ እቅድ ነው ያለው? በእርስዎ አስተያየት የሕገወጥ ይዘታ ቤቶችን ማፍረስ በተጠቁው ነዋሪዎች ኑሮ ላይ ያለውን ተጽእኖ እንዴት ይገልጹታል?(ለከተማ ልማት ቢሮ፤ለመሬት ማኔጅመንት ዳይሬክቶሬት)

4. What are the food security situations of the sub-city? Which weredas are highly affected by food security? Can you mention the number of households in need of grave food assistance based on recent figure from food for work program or other program? Is there a plan or practice to improve the livelihood of the dwellers assisted by food for work in sustainable manner?

የክፍለ ከተማው በምግብ ራስን የመቻል አቅሙን እንዴት ይገልጹታል? ምን ያህል አባወራ በምግብ ለስራ ወይም በሌላ ፕሮግራም ይረዳል? በምግብ ለሥራ የሚረዱ ነዋሪዎችን ህይወት በዘላቂነት ለማሻሻል በክፍለከተማው ምን የተፈጸመ ሥራ ወይም እቅድ አለ? (ለምግብ ለሥራን የሚያስተባብር ቢሮ)

Part-1: Questionnaire for Wereda

1. Are the poverty alleviations and services provisions that has been performed by the formal institutions of the government benefitted the needy people in inner-city slum (Werda 07Addis Ketema) and informal settlements (Wereda 03 Kolfe Keranyo)? If yes, on what development activities (micro finance and credit, school provision, health provision, sanitation services, water services, road provision) the inner-city slum of Addis Ketema Wereda 07 and Kolfe Keranyo wereda 03 informal settlements were benefitted?

የመንግስታዊ ተቋማት በድህነት ቅነሳ ላይና በልማትና አገልግሎት ዘርፍ ስራዎች የሚከናወኑ ትግባራት (ለጥቃቅንና አነስተኛ ተቋማት ድጋፍ በማድረግ ፤ በጤና አገልግሎት፤ በሳኒቴሽን አገልግሎት፤ የውሀ መስመር በመዘርጋት፤ በመንገድ ግንባታ ፤ በትምህርት ቤት አገልግሎት) ምን ያህል የኮልጌ ቀራንዮ የወረዳ 03 የህገወጥ ሰፈራ አካባቢዎችን እና የአዲስ ከተማ የወረዳ 07 ነዋሪዎችን ተጠቃሚ አንዳደረገ ቢያብራሩልን? (የወረዳው ቢሮ ኃላፊ ወይም የሚወክለው ባለሙያ)

2. Can you elaborate the dwellers' capability and experience to mobilize their resources, based on their own initiation and will, to improve their livelihood through engaging in different development activities?

የነዋሪው ሕብረተሰብ ያለውን እምቅ ሁብት አስተባብሮ በራሱ ተነሳሽነት እና ፍቃድ ወረዳውን ለማልማት፤ እንዲሁም የገዛ ኑሮውን ለማሻሻል የሚያደርገውን ጥረትና ተሞክሮ ካለ በዝርዝር ቢያብራሩልን ? (የሚመለከተውን የወረዳውን የሕብረተሰብ ማስተባበሪያ ክፍል የወረዳው)

3. Which local institutions of the wereda are working on development activities and poverty alleviations? Can you elaborate what has been achieved so far by the specific sector of the community local organizations on poverty alleviation for Addis Ketema Wereda 07 inner-city and Kolfe Keranyo Wereda 03 informal settlement?

የትኛው በወረዳው ያለ የህብረተሰቡ ተቋም (እድር፣ እቁብ ፤ የሴቶች ማህበር ፤ የመረዳጃ ማህበር --ወዘተ) በድህነት ቅነሣ ላይ ይሠራል? እስካሁን እነዚህ የሕብረተሰቡ ተቋማት በድህነት ቅነሳ ስራ ላይ ያከናወኗቸውን ተግባራትና ያመጡትን ለውጦች በዝርዝር ቢያብራሩልን ይችላሉ? (ጥቃቅንና አነስተኛ የሚመለከተው ክፍል)

4. Are there any Non-Government Organizations (NGO's) that worked on improving the livelihood of the poor in Addis Ketema Wereda 07 and Kolfe Keranyo Wereda 03 peri-urban?

የኢመንግስታዊ ተቋማት ድህነትን ለመቀነስ እና በአካባቢ ልማት በወረዳው ላይ የሚሳተፉ ከሆነ በዝርዝር ቢያብራሩልን(የወረዳው ቢሮ ኃላፊ ወይም የሚወክለው ባለሙያ)

5. What are the capabilities and participation of the dwellers on improving their livelihood-constructing constructing road, participating on spring development, house construction, job creation, and flood protection, participation in school/health facility construction, preventing pollution of river, planting nurseries and environment protection)?
6. What prevented the dwellers for exhaustively utilizing their capability and potential for improving their livelihood?

የወረዳው ሕብረተሰብ በልማት ላይ ያለውን አቅምና ተሳትፎ በማቀናጀት ኑሮውን ለማሻሻል (አካባቢን በመጠበቅ፣ ቤት በመስራት፣ መንገድ በመስራት ፣ ትምህርት ቤትና ጤና ጣቢያ በመስራት፣ ውሃና ምንጭ በማጎልበት፣ ስራ እድል በመፍጠር፣ ሽንት ቤት በመስራት፣ ቆሻሻን በመሰብሰብና በማንጅመንት፣ ጎርፍን በመከላከል፣ የወንዝ ብክላን በመከላከል) ያለውን ተሳትፎ በዝርዝር ቢያብራሩልን? (ስለሕብረተሰብ ተሳትፎ የሚመለከተው የወረዳው ክፍል)

ሕብረተሰቡ ያለውን አቅምና እምቅ ሀብት አሟጦ ተጠቅሞ ኑሮውን እንዳያሻሽል ያደረገው ምክንያት ካለ ቢያብራሩልን? (ስለሕብረተሰብ ተሳትፎ የሚመለከተው የወረዳው ክፍል)

7. How was the past capital budget execution performance (2011 ETC and 2012 ETC) disaggregated by budget headlines/

ያለፈው ሁለት ተከታታይ አመት(የሁለት ሺህ አስራ አንድ እና አስራ ሁለት) የወረዳው የካፒታል በጀት አፈጻጸም በበጀት አርእስት ስንከፋፍለው እንዴት ነበር?

- 8. Which government institutions and in what intervention areas supported the different social groups (especially those who do not have land right, women, illiterate households, the poorest of the poor, the unemployed, the old age, migrants, homeless, women widowed/divorced, poor housing conditions)?
- 9. Is there a practice of urban upgrading and house maintenance through the involvement of the community? What difference the practice brings to improve the livelihoods of the poorest of the poor?

ከተማውን ለማደስና ለማሻሻል ፤የተጎሳቆለ ቤት ለማደስ ምን ምን አይነት ተግባራት ይፈጸማሉ፡፡

የተፈጸሙትስ ተግባራት ምን አይነት ለውጥ እንዳመጡ በቁጥር ጭምር በተደገፈ መልኩ ቢያብራሩልን ?

10.Is there crime activities on the wereda? What type of crime is most common in the wereda?How do you elaborate the crime activities in the wereda? Can you mention the number of community police in *ketena* or *sefer* what actions have been taken to fight crime and disorder?

በወረዳው አካባቢ የወንጀል ተግባራት ይፈጸማሉ፤ የሚከናወኑ ወንጀሎች ምን ምን ናቸው የወንጀል ተግባራት አፈጻጸምን እንዴት ይገልጹታል?

ወንጀልን ለመከላከል ምን ያህል የህብረተሰብ ፖሊስ በቀጠና ወይም በሰፈር አለ፤ ወንጀልን ለመከላከል የተወሰዱ እርምጃዎችን ቢያብራሩልን (ከወረዳው ቢሮ ጽ/ቤት ወይም የሚመለከተውን የወረዳው ክፍል በማነጋገር)

11. What are the top ten leading causes of morbidity in the Wereda?

10(አስር) ዋነኛ በወረዳው የሚታየው የጤና ስሜቶች ምንድናቸው?(ከሚቀርበው ጤና ጣቢያ)

Questionnaire 3.2: for Kolfe Keranyo Sub-city (kifle ketema) and Wereda 03

Mandatory conditions:

- Interview with pertinent officials and collecting documents.
- The name, position, organization and the address of the key informant shall be stated

Other pertinent documents:

- If necessary, other supporting documents need to be collected in relation to the interview

Questionnaires:

Part 1: Questionnaire for sub-city

5. Which formal institutions of the sub city are working on poverty alleviations?

የትኛው የክፍለ ከተማውና የመንግስት ተቋማት በድህነት ቅነሣ ላይ እንደሚሠሩ ቢያብራሩልን?(ለጥቃቅንና አነስተኛ ተቋማት ቢሮ፣ ለሴቶች ጉዳይ ቢሮ፣ ለአካባቢ ጥበቃ ቢሮ፣ የህብረተሰብ ተሳትፎ ማስተባበሪያ ቢሮ)

6. Which local institutions (Community Based organizations such as Edir and Ekub, Women Associations and other local assistance associations) of the sub/city are working on poverty alleviations and environment protection? Can you elaborate what has been achieved so far by the specific sector of the community local organizations on poverty alleviation and environment protection activities of the sub-city?

የትኛው በክፍለ ከተማው ያለ የህብረተሰቡ ተቋም (እድር፣ እቁብ ፤ የሴቶች ማህበር ፤ የመረዳጃ ማህበር --ወዘተ) በድህነት ቅነሣ እና በአካባቢ ጥበቃ ላይ ይሠራል? እስካሁን እነዚህ የህብረተሰቡ ተቋማት በክፍለ ከተማው ድህነት ቅነሳ እና በአካባቢ ጥበቃ ስራ ላይ ያከናወኗቸውን ተግባራትና ያመጡትን ለውጦች በዝርዝር ሊያብራሩልን ይችላሉ?

7. Is there an option to provide Legal tenure right for dwellers of informal settlements and those who constructed house illegally? What has been done so far for those houses constructed without legal municipal right? Is there a plan to demolish the currently existed illegal houses or demolishing them? If there is demolition practice, what were the consequences of demolishing houses on livelihood of the victim households?

በህገወጥ ቤት የገነቡ ነዋሪዎችን፤ በመጠለያ የሚኖሩትን ሕጋዊ የመሬት ይዘታ ማረጋገጫ ለመስጠት እቅድ አለ ? ከዚህ በፊት በህገወጥ መንገድ የገነቡት ላይ ምን ዕርምጃ እንደተወሰደ ቢያብራሩልን? አሁንስ በህገወጥ መንገድ ገንብተው ያሉ ህብረተሰቦችን ህጋዊ የማድረግ ነው ወይስ የማፍረስ እቅድ ነው ያለው? በእርስዎ አስተያየት የሕገወጥ ይዘታ ቤቶችን ማፍረስ በተጠቁው ነዋሪዎች ኑሮ ላይ ያለውን ተጽእኖ እንዴት ይገልጹታል?(ለከተማ ልማት ቢሮ፤ለመሬት ማኔጅመንት ዳይሬክቶሬት)

8. What are the food security situations of the sub-city? Which weredas are highly affected by food security? Can you mention the number of households in need of grave food assistance based on recent figure from food for work program or other program? Is there a plan or practice to improve the livelihood of the dwellers assisted by food for work in sustainable manner?

የክፍለ ከተማው በምግብ ራስን የመቻል አቅሙን እንዴት ይገልጹታል? ምን ያህል አባወራ በምግብ ለስራ ወይም በሌላ ፕሮግራም ይረዳል? በምግብ ለሥራ የሚረዱ ነዋሪዎችን ህይወት በዘላቂነት ለማሻሻል በክፍለከተማው ምን የተፈጸመ ሥራ ወይም እቅድ አለ? (ለምግብ ለሥራን የሚያስተባብር ቢሮ)

Part-1: Questionnaire for Wereda

12.Are the poverty alleviations and services provisions that has been performed by the formal institutions of the government benefitted the needy people in inner-city slum (Werda 07Addis Ketema) and informal settlements (Wereda 03 Kolfe Keranyo)? If yes, on what development activities (micro finance and credit, school provision, health provision, sanitation services, water services, road provision) the inner-city slum of Addis Ketema Wereda 07 and Kolfe Keranyo wereda 03 informal settlements were benefitted?

የመንግስታዊ ተቋማት በድህነት ቅነሳ ላይና በልማትና አገልግሎት ዘርፍ ስራዎች የሚከናወኑ ትግባራት (ለጥቃቅንና አነስተኛ ተቋማት ድጋፍ በማድረግ ፤ በጤና አገልግሎት፤ በሳኒቴሽን አገልግሎት፤ የውሀ መስመር በመዘርጋት፤ በመንገድ ግንባታ ፤ በትምህርት ቤት አገልግሎት) ምን ያህል የኮልፌ ቀራንዮ የወረዳ 03 የህገወጥ ሰፈራ አካባቢዎችን እና የአዲስ ከተማ የወረዳ 07 ነዋሪዎችን ተጠቃሚ አንዳደረገ ቢያብራሩልን? (የወረዳው ቢሮ ኃላፊ ወይም የሚወክለው ባለሙያ)

13. Can you elaborate the dwellers' capability and experience to mobilize their resources, based on their own initiation and will, to improve their livelihood through engaging in different development activities?

የነዋሪው ሕብረተሰብ ያለውን እምቅ ሀብት አስተባብሮ በራሱ ተነሳሽነት እና ፍቃድ ወረዳውን ለማልማት፤ እንዲሁም የገዛ ኑሮውን ለማሻሻል የሚያደርገውን ጥረትና ተሞክሮ ካለ በዝርዝር ቢያብራሩልን ? (የሚመለከተውን የወረዳውን የሕብረተሰብ ማስተባበሪያ ክፍል የወረዳው)

14. Which local institutions of the wereda are working on development activities and poverty alleviations? Can you elaborate what has been achieved so far by the specific sector of the community local organizations on poverty alleviation for Addis Ketema Wereda 07 inner-city and Kolfe Keranyo Wereda 03 informal settlement?

የትኛው በወረዳው ያለ የሀብረተሰቡ ተቋም (እድር፣ እቁብ ፤ የሴቶች ማህበር ፤ የመረዳጃ ማህበር --ወዘተ) በድህነት ቅነሣ ላይ ይሠራል? እስካሁን እነዚህ የሕብረተሰቡ ተቋማት በድህነት ቅነሳ ስራ ላይ ያከናወኗቸውን ተግባራትና ያመጡትን ለውጦች በዝርዝር ቢያብራሩልን ይችላሉ? (ጥቃቅንና አነስተኛ የሚመለከተው ክፍል)

15. Are there any Non-government Organizations (NGO's) that worked on improving the livelihood of the poor in Addis Ketema Wereda 07 and Kolfe Keranyo Wereda 03 peri-urban?

የኢ.መንግስታዊ ተቋማት ድህነትን ለመቀነስ እና በአካባቢ ልማት በወረዳው ላይ የሚሳተፉ ከሆነ በዝርዝር ቢያብራሩልን(የወረዳው ቢሮ ኃላፊ ወይም የሚወክለው ባለሙያ)

- 16. What are the capabilities and participation of the dwellers on improving their livelihood-constructing constructing road, participating on spring development, house construction, job creation, and flood protection, participation in school/health facility construction, preventing pollution of river, planting nurseries and environment protection)?
- 17. What prevented the dwellers for exhaustively utilizing their capability and potential for improving their livelihood?

የወረዳው ሕብረተሰብ በልማት ላይ ያለውን እቅምና ተሳትፎ በማቀናጀት ኑሮውን ለማሻሻል (አካባቢን በመጠበቅ፣ ቤት በመስራት፣ መንገድ በመስራት ፤ ትምህርት ቤትና ጤና ጣቢያ በመስራት፣ ውሃና ምንጭ በማጎልበት፣ ስራ እድል በመፍጠር፣ ሽንት ቤት በመስራት፣ ቆሻሻን በመሰብሰብና በማንጅመንት፣ ጎርፍን በመከላከል፣ የወንዝ ብክላን በመከላከል) ያለውን ተሳትፎ በዝርዝር ቢያብራሩልን? (ስለሕብረተሰብ ተሳትፎ የሚመለከተው የወረዳው ክፍል)

ሕብረተሰቡ ያለውን እቅምና እምቅ ሀብት አሟጦ ተጠቅሞ ኑሮውን እንዳያሻሽል ያደረገው ምክንያት ካለ ቢያብራሩልን? (ስለሕብረተሰብ ተሳትፎ የሚመለከተው የወረዳው ክፍል)

- 18. How was the past capital budget execution performance (2011 ETC and 2012 ETC) disaggregated by budget headlines/

ያለፈው ሁለት ተከታታይ አመት(የሁለት ሺህ አስራ አንድ እና አስራ ሁለት) የወረዳው የካፒታል በጀት አፈጻጸም በበጀት አርእስት ስንከፋፍለው እንዴት ነበር?

- 19. Which government institutions and in what intervention areas supported the different social groups (especially those who do not have land right, women, illiterate households, the poorest of the poor, the unemployed, the old age, migrants, homeless, women widowed/divorced, poor housing conditions)?
- 20. Is there a practice of urban upgrading and house maintenance through the involvement of the community? What difference the practice brings to improve the livelihoods of the poorest of the poor?

ከተማውን ለማደስና ለማሻሻል ፤የተጎሳቆለ ቤት ለማደስ ምን ምን አይነት ተግባራት ይፈጸማሉ፡፡

የተፈጸሙትስ ተግባራት ምን አይነት ለውጥ እንዳመጡ በቁጥር ጭምር በተደገፈ መልኩ ቢያብራሩልን ?

21. Is there crime activities on the wereda? What type of crime is most common in the wereda? How do you elaborate the crime activities in the wereda? Can you mention the number of community police in *ketena* or *sefer* what actions have been taken to fight crime and disorder?

በወረዳው አካባቢ የወንጀል ተግባራት ይፈጸማሉ፤ የሚከናወኑ ወንጀሎች ምን ምን ናቸው የወንጀል ተግባራት አፈጻጸምን እንዴት ይገልጹታል?

ወንጀልን ለመከላከል ምን ያህል የህብረተሰብ ፖሊስ በቀጠና ወይም በሰፈር አለ፤ ወንጀልን ለመከላከል የተወሰዱ እርምጃዎችን ቢያብራሩልን (ከወረዳው ቢሮ ጽ/ቤት ወይም የሚመለከተውን የወረዳው ክፍል በማነጋገር)

22. What are the top ten leading causes of morbidity in the Wereda?

10(አስር) ዋነኛ በወረዳው የሚታየው የጤና ስሜቶች ምንድናቸው?(ከሚቀርበው ጤና ጣቢያ)

Annex-4

sample of ground verification points: slum/informal settlement, regularized informal, and formal settlement

Sub city	Chirkos
Name of Point	Point name: CH-006
Relative Location	Near Kera (Admas Hotel) 340 meter from Beklo Bet
X_coordinate(UTM)	472878
Y_coordinate (UTM)	994440
Residential Neighborhood Characteristics	
Dominant building	<input type="checkbox"/> Standard Building <input checked="" type="checkbox"/> Sub-standard building <input type="checkbox"/> Mix of standard and sub-standard building
Road type	A) Cobble B) Asphalt C Block Stone D) Gravel E) Unpaved/Earth
Decision	A) Formal B) Regularized Informal C Informal/slum

Note: a mix of residence with sub-standard and standard building with paved road (Cobble/Asphalt) are categorized as “Regularized Informal”

Pic 5: near kera 340 meters from Beklo Bet NC near Admas Hotel point, CH_006



Name of Point	Bole 08
Relative Location	<u>Near Yearer Gerji Kidus Giorgis Church</u>
X_coordinate	480062
Y_coordinate	0994273
Residential Neighborhood Characteristics	
Dominant building	<input type="checkbox"/> Standard Building <input checked="" type="checkbox"/> Sub-standard building <input type="checkbox"/> Mix of standard and sub-standard building
Road type	A) Cobble B) Asphalt C) Block Stone D) Gravel <input checked="" type="checkbox"/> E) Unpaved/Earth
Decision	<input type="checkbox"/> A) Formal <input type="checkbox"/> B) Regularized Informal <input checked="" type="checkbox"/> C) Informal/slum

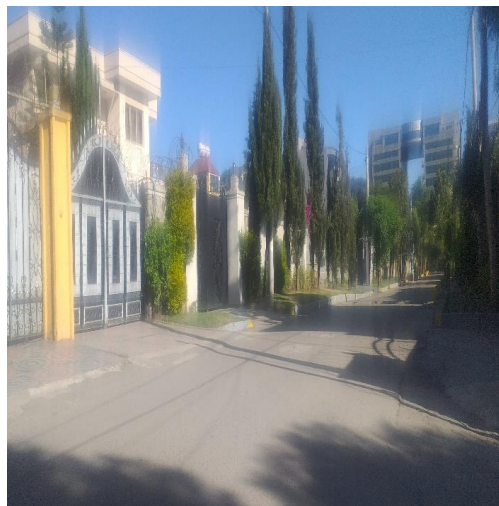


Sub city	Akaki Kaliti
Name of Point	Point name <u>KA-06</u>
Relative Location	600 meter south east of Tirunesh Beijing General hospital
X_coordinate	476782
Y_coordinate	979153
Residential Neighborhood Characteristics	
Dominant building	<input type="checkbox"/> Standard Building <input type="checkbox"/> Sub-standard building <input checked="" type="checkbox"/> Mix of standard and sub-standard building
Road type	<input checked="" type="radio"/> A) Cobble B) Asphalt C) Block Stone D) Gravel <input type="radio"/> E) Unpaved/Earth <input type="radio"/> F) Red Ash Road
Decision	<input type="radio"/> A) Formal <input checked="" type="radio"/> B) Regularized Informal C) Informal/slum

Note: a mix of residence with sub-standard and standard building with paved road (Cobble/Asphalt) are categorized as “Regularized Informal”




Sub city	Nifas Silk
Name of Point	Point name P-01
Relative Location	Bisrate Gebrial, Queens Supermarket
X_coordinate	469613
Y_coordinate	993717
Residential Neighborhood Characteristics	
Dominant building	<input checked="" type="checkbox"/> Standard Building <input type="checkbox"/> Sub-standard building <input type="checkbox"/> Mix of standard and sub-standard building
Road type	<input checked="" type="radio"/> A Cobble B) Asphalt C) Block Stone D) Gravel <input type="radio"/> E) Unpaved/Earth
Decision	<input checked="" type="radio"/> A Formal B) Regularized Informal C) Informal/slum



Annex 4 articles

Article

The Spatial Pattern of Deprivations and Inequalities: The Case of Addis Ababa, Ethiopia

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Abstract: Addis Ababa is a metropolitan area faced with the challenges of Ethiopia's urbanization, such as poverty, unemployment, informal settlements, an acute housing shortage, and environmental hazards. Yet, the non-practicality of area-based policy using the Multiple Deprivation Index (MDI) exacerbates the polarization of poverty and spatial inequality to create a divided city. The study developed the MDI for 2007 and 2016. The study's objective was to justify the area-based policy by analyzing the overlaps of deprivations based on the relationship of pertinent indicators and components, the spatial pattern of inequality and deprivations, and the relationship of deprivation with population size and density. The findings of the study were triangulated and validated with the deductive theoretical, empirical, and SDG frameworks to replicate external validity. The research design included both descriptive and correlational methods. The inductively derived pattern using PCA (principal component analysis) and LISA (local spatial association index) of MDI components revealed spatial inequality and poverty polarization. The index of concentrated poverty was revealed by global spatial autocorrelation. The statistical and spatial trend analysis revealed concentrated poverty, especially in the inner-city slums and the peri-urban informal settlements. Most of the findings conformed to deductive theoretical and SDG frameworks, while the analysis of MDI indicators and components revealed additional slum indicators and the relevance of integrating other SDG indicators with SDG 11 for realizing sustainable urbanization. Due to spatial inequality, patterns of concentrated poverty, a large, deprived population, and easing future urbanization challenges, the study rationalized area-based policy for reducing inequality and poverty polarization.

Keywords: multiple deprivation index (MDI); area-based targeting; spatial inequality; principal component analysis (PCA); spatial autocorrelation; SDG (sustainable development goal); concentrated poverty



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1. Introduction

Development is not sustainable if people are excluded from opportunities, services, and a better life. Thus, SDG (Sustainable Development Goal)-10 calls for reducing inequalities in income, age, sex, disability, race, ethnicity, and economy [1]. Because of concentrated poverty, spatial inequality as measured by the Gini coefficient has not improved significantly in SSA (Sub-Saharan Africa), including Ethiopia, in recent years [2]. Ethiopia's urban inequality showed a slight increase from 0.29 in 1995 to 0.37 in 2010–11 and 0.38 in 2015–16, with more inequality in urban than rural areas [3–5]. Recent developments show that the income gap in Ethiopian cities is widening, with the bottom 10% of the population earning only 4% of the total income [6]. Increasing urbanization leads to higher income inequality because cities that produce more GDP attract more migrants from rural areas [7]. This is particularly true in the case of Addis Ababa, where rural-urban migration governs the

urbanization of Addis Ababa [8], and migrants account for 42 percent of its population [9]. Regardless of the persistent face of inequality, the Addis Ababa headcount poverty index was 16.8% in 2015/16, a significant improvement from 28.1% in 2010/11 [3,4]. Ethiopia's level of urbanization was 21.2 percent in 2019 [10] and is projected to reach 37 percent in 2035 [11], assuming that the country's urban growth rate is 5.4 percent per year [11,12].

In Ethiopia, urbanization has not been associated with a commensurate increase in economic prosperity. For instance, 23.5 percent of households (HHs) in Addis Ababa have recently reported the presence of unemployed adults [12]. To achieve middle-income status, Ethiopia needs to address the challenges of rapid urbanization, such as deepening poverty, high unemployment rates, the rapid expansion of informal settlements, an acute housing shortage, and the growing risk of environmental hazards [11]. Pro-poor spending in Ethiopia amounted to 65.7 percent of the total public expenditure in 2015/16 [4], while the reduction in non-monetary welfare (health, education, sanitation, and access to water) was at a low level [13]. Ethiopia should meet SDG target 1.2 of reducing by half the proportion of men, women, and children of all ages living in poverty in all its dimensions [14]. The MDI (Multiple Deprivation Index) is a means to link and monitor SDGs since it considers and weighs a multitude of problems. There is a link between SDG 4 on education, SDG 1 on poverty, and SDG 8 on employment. The above links are justified by the fact that education reduces poverty by increasing people's income and improving workers' productivity and productive capabilities. Yet, there is less evidence of the link between urban development (SDG 11) and education (SDG 4), except for the link between SDG 4 on education and SDG 11 on disaster management [15].

The development of MDI tools that monitor SDGs in an integrated manner and target resources to vulnerable, poor, and deprived areas will bridge the spatial inequality gap and reduce poverty's multidimensional problems. Nonetheless, the use of the MDI for resource allocation and prioritizing is less common in most countries in SSA. Addis Ababa allots a capital budget for sub-cities based on a sector-based approach that considers the unit cost of the project, population, and level of development [16] despite the large and disproportionately deprived population and enduring spatial inequality. In Ethiopia, the percentage of people living with multidimensional poverty (in terms of education, health, and living conditions) is 88% [17]. The non-monetary indicators [large HHs, high dependency rate, and lack of education] are the main characteristics of poor people in Ethiopia [18]. Urban inequality is rising in Ethiopia, from 0.29 in 1995 to 0.38 in 2016 [4]. As a result, the pragmatic application of MDI for disaggregated small neighborhood units (kebeles) reduces inequality and deprivations by implementing compensatory policies for targeted beneficiaries (i.e., in terms of poverty alleviation, the safety net, and social security), and prioritizing urban regeneration areas. MDI tools are useful for interpreting spatial inequality and developing a composite index for multidimensional deprivations. The MSAT (Multivariate Statistics Analysis Technique) is one of the empirical approaches to developing MDI that reflects the multifaceted nature of poverty faced by the urban poor. The MSAT's inductively derived pattern validation with the theoretical, empirical, and SDG frameworks enriches the local context pattern's replicabilities in other contexts and settings. The MSAT is a suitable instrument for refining the most crucial indicators among a multitude of deprivation indicators. As a result, it is useful for proper policy targeting, resource allocation, and figuring out the critical factors that explain concepts and theories [19–21]. Therefore, the first research question is stated as follows: "Which deprivation indicators are most strongly correlated with the main components of the MDI?" The main components of the MDI 2007 and 2016 explain the main factors to address in order to resolve the overlaps of deprivation and inequality experienced by the urban poor. The study used PCA (principal component analysis) over other MSAT approaches. This is because PCA is robust for maximizing the variance of variables and has other advantages detailed in the methodology sections of this work. The study interprets the inductively derived pattern of deprivations by analyzing the relationship between the crucial components and indicators of the MDI based on PCA using the SPSS (Statistical

Package for Social Science). The study discusses the rationale for area-based policy in light of the relationship between MDI indicators and components and the spatial patterns of the MDI components. The triangulation of the theoretical, empirical, and SDG frameworks validated and enriched the findings obtained regarding the interrelationships of indicators and components (Supplementary Materials).

Spatial inequality is caused by unequal distributions of income, resources, and infrastructure [22]. In Ethiopia, there is more inequality in urban than rural areas [5]. The poorest 10% of Ethiopia's population has not experienced income growth since 2005 [13,17], which substantiates the grave social inequality and social exclusion. Spatial inequality and poverty polarization are enduring facts since the destitute and vulnerable are concentrated in informal settlements and slums, while the rich are segregated into formal neighborhoods. Slums constituted 80 percent of the inner city of Addis Ababa [23]. In Addis Ababa, 66% of the population lives in informal settlements that cover about 44% of the city's built-up area [24]. Area-based targeting is rational for Addis Ababa, a city that is characterized by high rates of population, noticeable spatial inequality in access to good housing and basic urban services, as evidenced in its persistently high rates of unemployment, the worrisome incidence of poverty, and the conspicuous proliferation of informal settlements [11,12,25]. In 2017, Ethiopia spent 66.7% of its budget on anti-poverty interventions. The Urban Productive Safety Net Program (UPSNP) of Ethiopia has made some progress in the social inclusion of the poor, in improving their access to social services, and in enhancing their livelihood capital asset accumulations [26]. Nonetheless, the non-monetary dimensions of welfare, such as education, health, and access to water and sanitation, remain low [17]. Therefore, there is a need to align high pro-poor spending with spatially guided welfare-disadvantaged areas to know and prioritize locations to target resources for beneficiaries or perform urban regeneration interventions. In this regard, analyzing the spatial patterns of multidimensional factors or components is useful to prioritize strategic areas that need interventions to reduce spatial inequality and design policies to reduce the negative neighborhood effect of poverty concentration. Based on the preceding fact, the second research question is stipulated as follows: "Where are the highest and lowest deprivation concentration kebeles (neighborhood units) of Addis Ababa based on the spatial pattern of MDI components?" The study used the spatial autocorrelation tools of Moran's I to obtain an index for the city-wide deprivation concentration and the LISA (the local index of spatial association) to analyze the high and low deprivation concentration neighborhood units of Addis Ababa. Then, the study made policy recommendations based on its findings. The findings (for the first and second research questions) were triangulated for enriching internal validity, and then the triangulated findings are discussed in relation to theoretical, empirical, and SDG frameworks.

Area-based targeting offers completeness and efficiency in the case of the spatial concentration of poor individuals, reducing the negative neighborhood effect of poverty concentration through providing public goods and fund rationing [27,28]. The area-based approach supports the people-based approach to prioritize areas for extending economic resources and social protection measures to meet SDG 1 [29,30]. However, vulnerable people are numerous and disproportionately overcrowded in Addis Ababa's slum areas [24,31], resulting in a divided city. For Addis Ababa, the purely inner-city slum sub-cities accounted for 32.5% of the 2016 projected population [32], which was concentrated in 7.8% of the Addis Ababa area. The overall inner-city slum accounted for 40 percent of the population and 11 percent of the area of Addis Ababa [33]. In addition, the city periphery of Addis Ababa houses destitute and massive rural migrants, who acquire land through squatting or informal land transactions [8,34], while there are also some inner city squatters [31,35] and temporary and recent migrants in parts of the inner city slum [34]. Due to concentrated poverty, informal houses host a large and highly overcrowded poor population; as many as 35% of the residents of the inner-city slum live in single-room accommodations [36]. The current housing crisis in Addis Ababa is due to the escalating rural exodus to Addis Ababa [36]. Thus, rural-urban migration is the major factor driving urbanization [8] and

poverty concentration. Concentrated poverty is defined as the “spatial distribution of socio-economic deprivation”, specifically focusing on the density of poor populations [37]. The theoretical frameworks substantiate the relationship between the pattern of concentrated poverty and population in the context of the global North [38–40]. The suburbanization of urban jobs and the exodus of middle-class blacks to white neighborhoods caused the concentration of underclass black people in American cities [38]. Alonso’s bid rent model claimed that the poorest houses, poor people, and substandard buildings are concentrated on the outskirts of the city because the inner city is not affordable for the poor [39]. Moreover, the city center has a higher land value and population concentration than other areas, according to Alonso’s model [40]. In the Ethiopian context, a link was established between urban forms and impoverished areas. Thus, concentrated poverty is higher in urban forms such as inner-city slums and peri-urban areas, while it is lesser in intermediate areas [41].

The empirical findings from the 122 World Bank poverty-targeted social programs showed that sector-based spending benefits the wealthy and that a quarter of these programs benefit non-poor people [42]. The preceding justifications point to the need for a policy framework, tools, and budget to better target vulnerable populations [29] living in high-poverty areas. In such cases, the MDI provides a tool to target and prioritize deprived populations. Currently, urban inequality and poverty polarization are rising in Ethiopia, which requires welfare-oriented strategies to better target compensatory budgets for vulnerable women and uneducated and impoverished HHs [5]. The analysis of locations with large, disproportionately deprived populations will assist in justifying the need for compensatory area-based policy to reach the more deprived populations, reduce spatial inequality, and address their preferences through participation and partnership. Given this fact, the third and fourth research questions address the relationship between deprivation and population size and density. The third and fourth research questions are stated, respectively, as follows: (3) What proportions of the sub-city population of Addis Ababa were most deprived? (4) Are there statistical correlations and spatial relationships between the MDI deprivation score and population density? The rationales for area-based policy are debated and justified by relating the findings of the above research questions to the theoretical, SDG, and empirical frameworks. The proportion of the most deprived population by sub-city is analyzed by descriptive statistics, and the statistical relationship between the deprivation score and population density is analyzed using PPMC (Pearson Product Moment Correlation). By comparing MDI 2007 and MDI 2016, the study interprets the spatial profile and trends of MDI deprivation scores as well as population density. The profile section stretches from the old inner city CBD (Central Business District) of the Addis Ketema sub-city to the Akaki Kaliti sub-city. Given that it was an old peri-urban informal settlement prior to the 2007 census, the profile trend extends to the Akaki-Kaliti sub-city fringe.

The study demonstrates how to generate a theoretical explanation for multiple deprivations and spatial inequality based on the pattern of relationships and overlaps of indicators and components derived in the inductive approach and triangulated with the spatial pattern of PCA components and deductive frameworks. The spatial inequality and poverty polarization in kebele (Addis Ababa’s lowest administrative units), dominated by informal settlements, implied the need for area-based resource targeting for disaggregated small area units. The analysis of the deprivation patterns in line with theoretical, empirical, and SDG frameworks will enrich the external validity of the research in other contexts. Policymakers, planners, and multilateral and bilateral agencies can use the MDI for a range of applications. The MDI is useful for resource allocation, compensatory policy, tax exemption, and prioritizing poverty and social security beneficiaries. Furthermore, the MDI is used to promote community partnerships coupled with urban regeneration.

2. Evaluation of Multiple Deprivations and Policy Implications

2.1. Brief Overview of the Area and People-Based Policy Debate

There are debates on the pros and cons of people-based or place-based policies. Place-based policies are geographically targeted, with the intent and structure of helping disadvantaged residents in them. People-based policies help disadvantaged people without regard to where they live or how concentrated they are [43]. The goal of the program matters when adopting a place-based or people-based policy. If the poverty concentration is particularly pronounced (e.g., in the urban core), the location might help policymakers identify the intended beneficiaries. Nonetheless, if the goal is to improve access to low-income housing, a people-based program of vouchers is less wasteful and more targeted [28]. The 2009 World Bank report argued that governments should focus on economic concentration and people-based policies by providing universal welfare services at early stages of development for disadvantaged locations. Yet, spatial targeting is recommended for countries with high levels of urbanization, divided cities, large regional disparities, and small economies isolated from the world market [25].

Yet, area-based policies have a multitude of benefits from many perspectives [25,27,28,44–46]. The area-based policy makes sense for compensating areas with overlapping and coexisting problems, reducing spatial inequality, and reaching large, deprived populations who suffer disproportionately [44]. Area-based policies can help reduce residential segregation, bring about spatial and social justice, provide a framework for community planning and development, and reach some vulnerable sub-groups [25,27,45,46]. Residents of concentrated poverty frequently face more than limited individual resources. The provision of public goods (such as good education and crime reduction) has positive neighborhood and social network effects on poverty alleviation [28]. Area-based initiatives in degenerating urban areas foster the active participation of residents and the voluntary sector in England and Germany [45]. Area-based targeting has also been applied in SSA, especially in the urban planning experience of fast-growing cities and agglomeration economies [47,48]. Kinshasa, a city with a high rate of urban growth and agglomeration economies, planned spatially targeted priority areas and institutional and infrastructure improvements [47]. Addis Ababa implemented area-based targeting for prioritizing urban upgrading based on the criteria that an area should be targeted as an “upgrading area” in the statutory plan if a high proportion of its housing is lacking drainage and sanitation facilities [48].

2.2. MDI Tools and Area-Based Policy

Policymakers have used MDI tools to implement area-based or geographically targeted policies rather than sector-based budget allocation and uniform transfer budgeting based on population and other criteria. Using area-based policy, efficiency in allocating resources for poverty alleviation will increase, and leakage to the non-poor will be reduced [49]. The area-based policy is pragmatic by developing an MDI. The MDI is a relative measure of multiple deprivations at a small-area level and a tool used for allocating resources for poverty alleviation and urban regeneration [50,51]. Different countries have explored the MDI in different contexts by employing different methodologies [52–59]. The Welsh government has used the MDI for urban regeneration in partnership with the community [52,53]. The MDI has been used in England since 1990 to distribute renewal funds, stimulate the housing market, and provide tax exemptions [54]. The English MDI used factor analysis to give weight to factors and combine indicators [55]. The USA used the Alkire Foster method, which was done by counting and analyzing the different types of deprivations individuals experience and then deriving a multidimensional poverty index (MPI) to identify who is poor [56]. UN-Habitat designed a poverty alleviation program for SSA secondary cities based on multiple deprivation indicators [57]. South Africa prioritized social service delivery for disadvantaged groups using the MDI, developed based on PCA [58]. The India Slum Severity Index is applied to comprehend the extent of housing problems as well as to know the most deprived slum population [59].

SDG 1 calls for a policy framework for allocating a budget that disproportionately benefits deprived women, the poor, and vulnerable groups [29]. In the case of poverty polarization and fund scarcity, area-based approaches using MDI support a people-based approach for prioritizing vulnerable groups to meet SDG 1. The MDI is effective to locate vulnerable people (older people, people with disabilities, mothers, and the jobless) that require social protection benefits in line with SDG target 1.3 [30]. The MDI is also pragmatic to prioritize by area the poor and vulnerable people that require economic resources and service access, in line with SDG 1 target 1.4 [29]. In sum, the MDI is a crucial tool for targeting and prioritizing deprived and vulnerable groups, anti-poverty programs, identifying areas of less opportunity and resources, efficient allocation of resources, urban regeneration, fostering community partnership and participation, tax exemption, preventive health service delivery, and analyzing housing problems. The limitations of the MDI include missing a deprived population living in non-deprived areas, being less useful for rural areas due to dispersed spatial patterns, and taking some years to construct trend data on a sufficient number of MDI indicators. Several countries have started to use the MDI as a policy tool, which requires attention in the future on how to interpret and translate indicators into policy decisions [60]. Nonetheless, there is little experience in exploring the MDI for a range of applications in SSA, where the polarization of poverty is rampant, except in some countries in the southern parts of Africa.

2.3. Multiple Deprivations Concept and Indicators

Many empirical studies have identified a variety of monetary and non-monetary domains and indicators for explaining deprivations. Deprivation is defined as a lack of resources of all kinds and opportunities, while poverty is a lack of financial resources to meet needs [61,62]. The specified material deprivation variables for the Townsend index were unemployment, non-car ownership, non-home ownership, and overcrowding of HHs [61]. The 2019 English index of deprivation includes seven domains: income, employment, education, health and disability, crime, barriers to housing services, and deprivation of the living environment [55]. Multiple deprivations include non-monetary indicators such as overcrowding, insufficient water supply, poor sanitation, poor housing, limited access to education, inadequate protection of rights, being voiceless, and so on [63,64]. The income indicator takes precedence over non-monetary deprivations because a lack of income exposes the poor to non-monetary deprivations [65]. Since the two dimensions measure different kinds of deprivation, both the monetary and non-monetary dimensions must be taken into account while developing the MDI [66].

The empirical analysis revealed that the deprivation of economically vulnerable groups is multifaceted [67]. Deprivation is associated with social exclusion and vulnerable group indicators: FHHs [female-headed households], age, and disability [68–71]. The spatial organization theory linked deprivations to the spatial pattern of vulnerable groups, claiming that FHHs are particularly concentrated in the city's urban core [69]. Deprivation areas are also associated with morphological factors from remote sensing imagery, such as building density, building size, and green or open space [72,73]. SDG 11 target 11.7 calls for accessing green and public spaces for vulnerable groups (women, children, older people, and people with disabilities) [29]. Thus, the integrated analysis of morphology and social and economic vulnerability helps monitor SDG target 11.7.

Deprivation also varied in line with urban and settlement forms. Indicators of deprived green or open space, aged buildings, vulnerable communities, an overcrowded population, degenerating infrastructure, and dilapidated housing conditions characterize the inner-city slum of Addis Ababa [23,31,36,74]. Yet, Addis Ababa's peri-urban informal settlements are identified by the absence of tenure rights and a lack of infrastructure, consisting mainly of poor, vulnerable rural-urban migrants who acquired land through the transaction of agricultural land [8,31,34]. The SDG 11 housing inadequacy indicators [tenure rights, improved water and sanitation, housing durability, and adequate living space] are deprivation indicators specified by the SDG so that countries monitor their

progress in meeting the intended goals and targets [14]. The declining inner city, planned and new development regions, and peri-urban informal settlements were the emerging urban forms in Ethiopian urban centers [41], reflecting the relationship between urban form and deprived areas.

3. Materials and Methods

3.1. Description of the Study Area

The city administration of Addis Ababa was made up of 10 sub-cities and 99 kebeles when this study began (Figure 1). The inner-city slum of Addis Ababa covered 11% of the total area, covering the sub-cities of Lideta, Kirkos, Addis Ketema, Arada, and some parts of the Kolfekeranyo, Gulele, and Yeka sub-cities [31]. The area of Addis Ababa based on the 2007 census area delineation was 52,743 hectares. The population density of Addis Ababa was 160 and 190 people per hectare in 2007 and 2016, respectively [75]. The density is increasing despite urban renewal having displaced 28,584 HHs from 2009–2016 in Addis Ababa [76], while since 2012, the Ethiopian government has focused on the redevelopment of the inner city for the accumulation of high-end developers [33]. The inner city is mostly made up of old, unplanned, dilapidated, and kebele rental housing stock, though some have their own private tenure rights and some inner-city squatters exist [31,35]. The inner city of Addis Ababa lies 4.5 km from the city's main CBD, covering an area of 6050 hectares and housing 40% of the city's population [33].

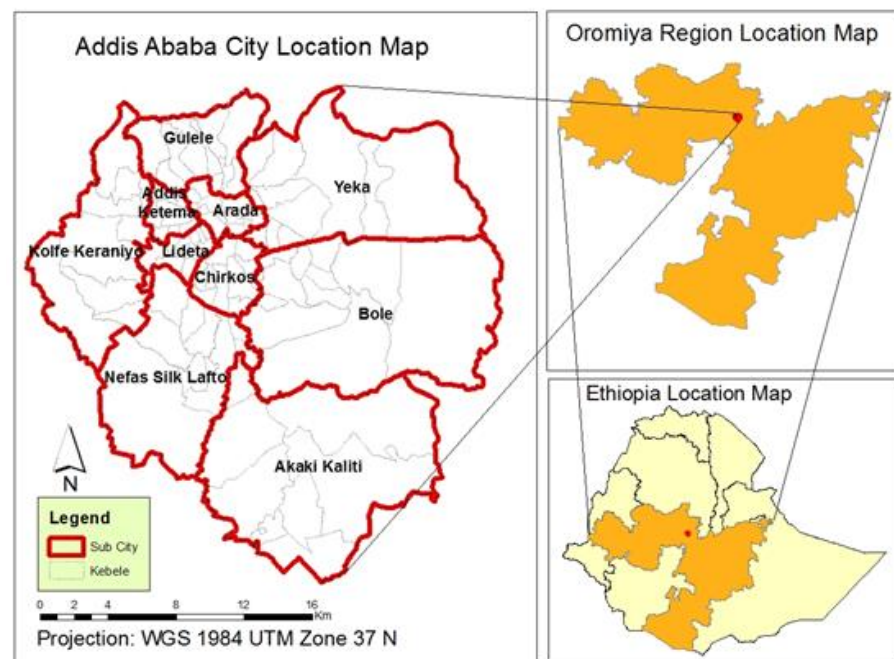


Figure 1. Sub-cities and Kebele boundary of Addis Ababa city.

The purely inner city consisted of 32 percent of the projected population [32], living in 7.8 percent of the area. The purely inner-city slum sub-cities are Lideta, Kirkos, Addis Ketema, and Arada. The old CBD is in the Addis Ababa inner-city market area of the Addis Ketema sub-city [77]. Merkato, situated in the old CBD, is the largest open market in Africa [78]. Based on a survey in wereda (a higher administrative unit next to a kebele) 07 of Addis Ketema sub-city, 39 percent of HHs rented beds for temporary and recent migrants [34]. The main expansion areas of squatter settlement are in the dominantly suburban sub-cities of Akaki Kaliti, Kolfe Keranyo, Yeka, and Bole [79]. The peri-urban informal settlement is an area subject to coercive bulldozing, little infrastructure, and uncertain or no tenure rights [31,35,41].

3.2. Socio-Economy and Other Characteristics of Addis Ababa as the Basis for MDI 2007

The population size of Addis Ababa, according to the results of the 2007 population and housing census, was 2,739,551, consisting of 628,985 housing units [80]. Housing tenure, including owner-occupied, rented, and rent-free housing, accounted for 32.6%, 61.45%, and 5.93% of the city's total housing units, respectively [80]. A total of 14.43% of the population aged five and older had never attended school. Migrants made up 47.6 percent of the total population. The migrant population for outside inner-city slum sub-cities was >50 percent for sub-cities (Bole, Nifas-Silk, and Kolfe-Keranyo) and 43 percent for the Akaki Kaliti sub-city. The disabled comprised 1.19% of the population [80]. The overall unemployment rate was 37.8% in 1999, 22.5% in 2007, and 21.2% in 2012 [80,81]. A total of 40 percent of the housing units had mud floors, 22.08% had no ceiling, and 98% had roofs made of corrugated iron sheets. For 76.89% of the housing units, the walls were built with mud and wood [80]. The average room number is 2.4 rooms per housing unit. Housing units with a tap inside the house and a tap in the compound constituted 5.83 percent and 25.89 percent, respectively. Housing with no sanitation facilities and housing with shared pit latrines constituted 14.3% and 41.1% of the housing stocks, respectively. A total of 86.25%, 40.79%, and 55.64% of the housing units have a radio, telephone, and TV, respectively [80]. Housing units with no bathroom and no kitchen room were 81.18% and 20.14%, respectively [80]. HHs that use electricity for cooking accounted for 34.71%. The average private and meter-shared electricity access in predominantly inner-slum sub-cities (Addis Ketema, Arada, Lideta, and Chirkos) was 99.2%, while the Addis Ababa average was 97.5% [80]. For the above-mentioned inner-slum sub-cities and Addis Ababa, the access to waste disposal services (including the municipality, private establishments, and individuals) was 85.1% and 69.6%, respectively [80]. About 70% of Addis Ababa's housing units were kebele and municipal rental houses, which were particularly concentrated in the inner city slums [31]. Based on the results of the 2018 survey conducted in the Addis Ababa case study area by the authors, 60% and 40% of the houses in the peri-urban squatter areas of Kolfe Keranyo sub-city and the inner-city slum area of Addis Ketema sub-city do not have a separate room for a kitchen, respectively.

3.3. Socio-Economic and Other Characteristics of Addis Ababa as the Basis for MDI 2016

The projected population size for 2016 was 3,352,000 [32]. Based on the SPSS 20 analysis of the 2015/16 HH expenditure survey data from the CSA (Central Statistics Agency of Ethiopia), the number of HHs was 3832 (44.02% of the HHs were female) in Addis Ababa. FHHs, with a widowed or divorced marital status, constituted 23.05 percent of the HHs. The disabled constituted 2.46 percent of the HHs. Unemployed and illiterate HHs made up 22.6% and 15.94% of the total HHs, respectively. HHs with a bachelor's degree or higher constituted 3.92 percent. Those aged 65 and above constituted 15.26% of the total HHs. Out of the HHs, 11.93% engaged in formal self-employment. Service workers and shop market sales accounted for 39.4% of self-employed formal businesses, followed by elementary (35.2%), craft-related (13.6%), and the remaining (11.8%) [4]. Based on the existing land use of Addis Ababa in 2017, the road and green area constituted 10 percent and 34.90 percent, respectively. Building footprint areas, calculated using a 2011 aerial photograph, covered 11% of Addis Ababa.

3.4. Methodological Procedure

CSA is the official data provider for monitoring and evaluation tools [3,4]. Ethiopia conducted censuses in 1984, 1994, and 2007. The government indefinitely postponed the 2018 census due to social unrest. The MDI 2007 used the population and housing census for 99 kebeles of Addis Ababa. The MDI 2016 used the 2016 CSA HH expenditure and socio-economic survey, the 2016 CSA population projection [32], the base map of the 2017 structure plan of Addis Ababa, the building footprints of the 2011 Addis Ababa aerial photograph, and the 2016 CSA population projection of Addis Ababa. The 2016 CSA HH expenditure survey covered 93 kebeles out of 99 kebeles in Addis Ababa. The requisite data

for the remaining six kebeles were estimated based on the average values of the surveyed kebeles that surrounded them.

The descriptive research design uses percentages, maps, or graphs to describe the situation. Moreover, the author’s previous research on case studies of peri-urban and squatter settlement areas of Addis Ababa [34], supported by the corresponding image interpretation for morphology and physical observation, enriched the interpretation and discussion of the findings. The correlational research design analyzes the relationship between multiple or two variables using the analytical methodologies of PCA, PPMC (Pearson Product Moment Correlation), LISA, and Moran’s I. The unitary weighting method and asking for opinions are simple but subject to arbitrary and subjective judgment [19]. The MSAT statistical weighting and ranking deprivations based on component (factor) scores provide an advantage relative to the non-statistical weighting method. In MSAT statistical weighting, the obtained factors clarify the general concept via an empirical link among a set of indicators, which makes the MSAT method appropriate for policy targeting [19–21]. MSAT’s inductive approach derives indicators, components, and patterns from observation and the development of explanations (theories) through a series of hypotheses [21]. PCA overrides other MSAT methods for the MDI model. The benefits of PCA are an orthogonal transformation of the original variables into a new set of variables, maximizing the variance of variables, and reducing redundancy. In addition, PCA derives small diagnostic factors from a large set of variables, and it is advantageous for giving more weight to unequally distributed assets between cases [82–85]. The study joins PCA results in SPSS 20 with the Kebele spatial unit of AA in ArcGIS 10.8 for GIS-based analysis. The overall methodological flows and procedures are illustrated in Figures 2 and 3. The methodological procedures are specified in a step-wise manner as follows:

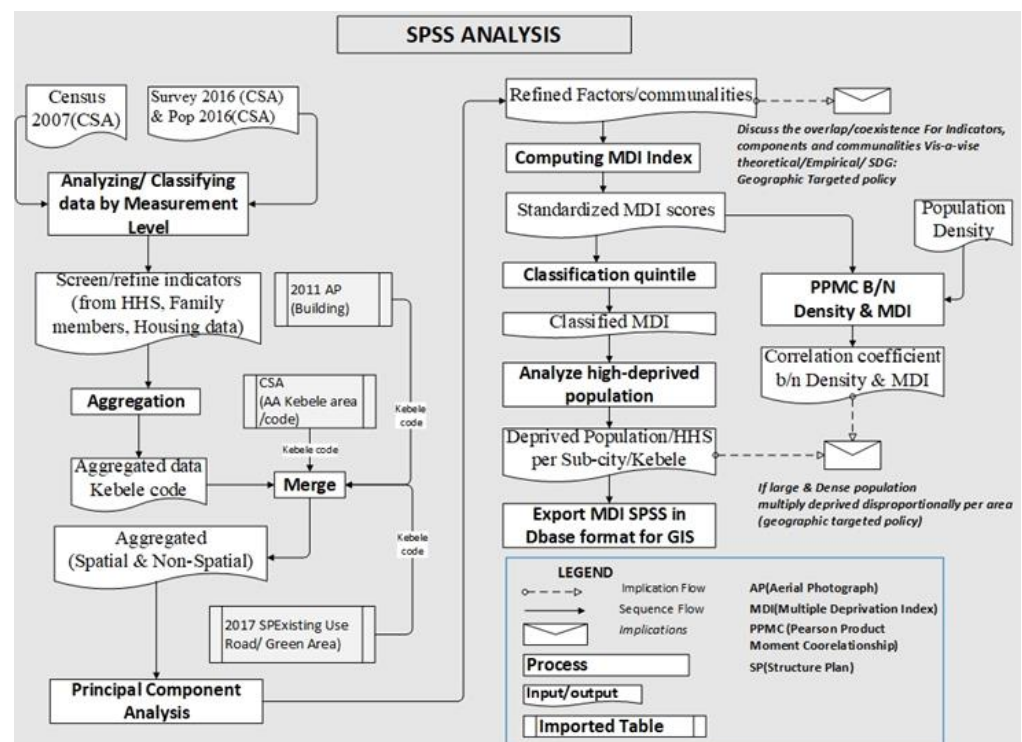


Figure 2. Methodological framework SPSS analysis.

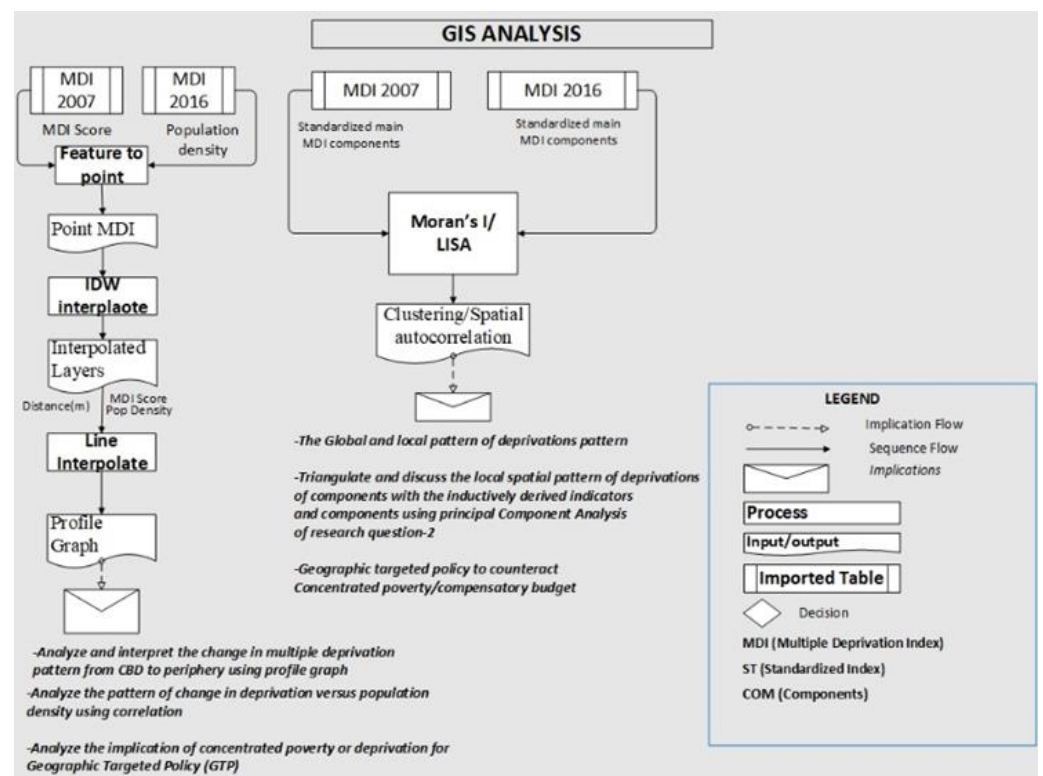


Figure 3. Methodological framework GIS analysis.

Step-1 Variable Selection and description

The SPSS correlation analysis refined 23 and 11 factors for MDI 2007 and MDI 2016, respectively. Kebele was the disaggregation unit for population and HH-level data. By screening variables, which measure the concept or construct, through the deductive theoretical lenses and the inductive empirical approach of MSAT, the research enhanced the internal validity of the variables. The SPSS correlation analysis refined 23 and 11 indicators or variables for MDI 2007 and MDI 2016, respectively. Kebele was the disaggregation unit for population and HH-level data. By screening indicators that describe the concept or construct through the deductive theoretical lenses and the inductive empirical approach of MSAT, the research enhanced the internal validity of the variables. The findings were triangulated within the theory, analysis, and SDG contexts to ensure external validity. The dimensions and indicators for MDI 2007 and MDI 2016 are described in Table 1.

Step 2: Assessing variables' appropriateness and factorability

Spearman's rank correlation coefficient (SMRCC) was used to screen candidate variables for PCA analysis. For MDI 2007 and MDI 2016, the factorial ecology model of PCA was applied in SPSS 20 to the screened variables by SMRCC. The PCA tool performed the orthogonal transformation of the observed variables (screened variables) into a new set of variables. Keyser–Meyer–Olkin (KMO) sampling adequacy tests the suitability of the data for PCA analysis. Due to the KMO being greater than 0.5 when comparing observed and partial correlation [86,87], the PCA analysis of indicators and components proceeded. The Bartlett test of sphericity (BTS) measures the factorability of the inter-correlation matrix. The BTS was less than 0.05, which implies that the null hypothesis that the correlation matrix is uncorrelated was rejected.

Table 1. Dimensions/factors, indicators, and description for MDI 2007 and MDI 2016.

Factors MDI 2007	Indicators	MDI Year	Indicator Description
Education	Illiterate population	MDI 2007	% of illiterate family members of the HHs
	Degree level education deprived	MDI 2007	% family members of the HHs with education < bachelor's degree level
Housing condition	Wall deprived	MDI 2007	% of housing with substandard wall materials (mud, wood, thatch, stones, and their combinations)
	Floor deprived	MDI 2007	% of housing with sub-standard floors (mud, bamboo reed, and their combinations)
	Ceiling deprived	MDI 2007	% of housing without ceiling
	Aged house	MDI 2007	% of housing age ≥ 20 years
Health	Deprived housing facilities	MDI 2007	% of housing-deprived of three facilities (radio, TV, house phone). For example, 0% deprived means HHs have three facilities, and 100% deprived means HHs have zero (no) facilities.
	Over crowdedness	MDI 2007	% of HHs over-crowdedness ≥ 2.5 person/room
Services and infrastructure	Population density	MDI 2007	2007 census population per kebele area in hectares)
	Own piped water-deprived	MDI 2007	% of housing using shared pipe tab, protected/unprotected well, river/lake/pond
	Sanitation-deprived	MDI 2007	% of housing with either a pit latrine shared by one or more HHs or no toilet at all
	Waste disposal-deprived	MDI 2007	% of housing that was not using public dump/private house collection
	Modern cooking-deprived	MDI 2007	% of housing which was not using gas and electricity for cooking
	Electric light-deprived	MDI 2007	% of housing that was not using electricity for lighting
Tenure	Bathing facility proportion	MDI 2007	% of housing with no bath facilities
	Kitchen-deprived	MDI 2007	% of housing with no specific kitchen room
	Private tenure owner deprivations	MDI 2007	% of housing whose occupant is not the owner of the house (the occupant is a renter or rent-free)
	Disabled population	MDI 2007	% of disability per population
	Migrant population	MDI 2007	% of migrants per population
Social Vulnerability	Widowed/divorced FHHs	MDI 2007	% of FHHs with marital status widowed or divorced
	Unemployment	MDI 2007	% of the unemployed population with age ≥ 10 years and <65 years per economically active population (10–64 age group based on Ethiopian census)
	Old dependency rate	MDI 2007	% of the population ≥ 65 years old per productive force population (15–64 age group)
	Young dependency rate	MDI 2007	% of the population with 0–14 years old per productive force population (15–64 age group)
Factors MDI 2016	Indicators/Variables	MDI Year	Indicator Description
Income	2016 Income per AE	MDI 2016	HH income per adult equivalent (AE) per month for 2016. AE indicates poverty measure is adjusted for the difference in the calorie requirements of different HH members (for age and gender of adult members).
Education	Illiterate HHs	MDI 2016	% HHs with illiterate educational status
	Non-degree HHs	MDI 2016	% HHs not having degree and above education status
Employment	Self-employed HHs	MDI 2016	% HHs employed in self-employed formal business.
	Unemployed HHs	MDI 2016	% HHs unemployed from economically active age group (10–64)
Social vulnerability	FHHs widowed/Divorced	MDI 2016	% FHHs with widowed/divorced marital status
	Older HHs	MDI 2016	% HHs with age 65 and above
Overcrowding	Population density	MDI 2016	2016 projected population per kebele area in hectares
	Building density	MDI 2016	Building footprint area percentage per kebele (based on 2011 15 cm aerial photograph)
Environment	Green per capita	MDI 2016	Green area coverage in meter square per 1000 population of kebele (based on existing land use prepared for the 2017 structure plan of Addis Ababa)
Infrastructure	Road per capita	MDI 2016	Road area coverage in hectares per 1000 population of kebele (based on existing road area for the 2017 structure plan of Addis Ababa)

Step-3: Refining Explanatory components

PCA is an orthogonal transformation of a system of variables x_1, x_2, \dots, x_n , into y_1, y_2, \dots, y_p . It has a mathematical form:

$$\begin{aligned} x_i &= b_{i1}y_1 + b_{i2}y_2 + b_{i3}y_3 + \dots + b_{ik}y_k \\ i &= 1, 2, \dots, n \\ k &= 1, 2, \dots, p, \end{aligned} \quad (1)$$

The number of empirical variables is equal to the number of components ($n = p$), and the total variance of the variable x_i is equal to the component variance y_k [88]. The PCA varimax rotation maximized the sum of the variances of the square loadings. Because of the rotation, each component has a small number of higher loadings, simplifying items' loadings by removing the middle ground [89]. Components with an Eigenvalue of greater than one indicated significant components, which explained most of the variance in the original data set. Component loading is the correlation between a specific observed variable and a specific component. Communality is the sum of all the squared factor loadings, and it is the same as r^2 in regression analysis [90]. The SPSS output of the rotated correlation matrix skipped the variable's loading score between -3 and 3 . The PCA interpretation skipped variables with a communality score of less than 0.3 due to the particular variable's weak relationship to a particular principal component [91]. The direction and strength of the relationships between the component's indicators, with high loading scores, were taken into consideration when naming the components.

Step-4: Develop a Non-Standardized Index (NSIMD) and a Standardized Index (MDI) of Multiple Deprivations

There are two MDI construction scenarios. Regarding the first scenario, only the first component that loaded highly on many variables was a measure of multiple deprivations [21]. The second scenario, the one used in this research, first developed NSMDI (non-standardized MDI), based on the percent of variance explained by components with eigenvalues > 1 , the total variance explained by considered components for the MDI, and the component score for each unit (Kebele) [86]. Secondly, the standardized MDI was developed by standardizing the NSMDI with a linear function between the absolute highest and lowest score [86,92]. Accordingly, the MDI summarizes complex dimensions of deprivation into a single, easy-to-use numeric representation [86,93]. The NSMDI formula is specified below.

$$NSMDI_t = \left(\frac{c1}{cs}\right) \times (f1) + \left(\frac{c2}{cs}\right) \times (f2) + \left(\frac{c3}{cs}\right) \times (f3) + \dots + \left(\frac{cn}{cs}\right) \times (fn) \quad (2)$$

The $NSMDI_t$ indicates NSMDI at time t , and t designates the agreed-upon MDI year setting. The designation code, $c1$ up to cn , denotes the variance explained by each component with an eigenvalue > 1 , where ci ranges from $c1$ to cn . $f1$ to fn are the component scores of each kebele unit of Addis Ababa, and fi varies from $f1$ to fn . cs is the sum of the variance explained by the components ($c1$ to cn). The MDI formula is specified below.

$$MDI_t = \left| \frac{(NSC - NLV)}{(NHV - NLV)} \right| \times 100 \quad (3)$$

The MDI_t designates MDI at time t (year). The designation NSC denotes the $NSMDI_t$ coefficient value of each kebele unit of AA. NLV denotes a low coefficient value for $NSMDI_t$, while NHV denotes a high coefficient value of $NSMDI_t$. The standardized MDI_t ranged from 0% (no deprivation) to 100% (maximum deprivation).

Step-5: MDI classification and analysis of the proportion of the "most deprived population".

The MDI is classified into quintiles using an equal-interval approach. The MDI ranged from a standardized score of 0% to 25% (low-deprived, or LD), $25\text{--}50\%$ (deprived, or

DE), 50–75% (high-deprived, or HD), and 75–100% (very high-deprived, or VHD). “Most deprived” comprised the HD and VHD.

Step-6: Preparing profile graph for deprivations/population density

ArcGIS software converted the MDI polygon layers to point layers and ran interpolation on the point layers using the Inverse Distance Weighting tool. The profile graph was derived in ArcGIS using the interpolated raster as the background layer. The profile graph modeled the spatial trend in deprivation score and population density as distance increased from the CBD to the periphery. The profile graph plotted the 20 km cross-section spanning from the old CBD towards the outskirts of the Akaki Kaliti sub-city of Addis Ababa. The profile graph pointed from the CBD to the Akakai Kaliti sub-city periphery (rather than other city fringe areas), as the Akaki Kaliti sub-city had peri-urban informal settlements before the 2007 census.

Step 7: Analyzing the spatial pattern of multiple deprivations: Moran’s I index and LISA (Local Spatial Autocorrelation)

“Moran’s I” is an index used to indicate the degree of spatial polarization of deprivations for this study. When similar standardized MDI component values cluster together, the index is positive, while the index is negative when dissimilar values cluster together. The MDI component value close to “0” indicates no spatial autocorrelation. Moran’s I give the overall spatial autocorrelation, but it is not useful to distinguish the variation in local spatial patterns of the MDI components [94]. Moran’s I statistic (I) for spatial autocorrelation and Z_I score (Z_I) for the statistics [94] are given as follows:

$$I = \frac{n}{s_o} \frac{\sum_{i=1}^n \sum_{j=1}^n w_{i,j} z_i z_j}{\sum_{i=1}^n z_i^2} \quad S_o = \sum_{i=1}^n \sum_{j=1}^n w_{i,j} \quad (4)$$

$$Z_I = \frac{I - E[I]}{\sqrt{V[I]}} \quad \text{Where: } E[I] = -1/(n-1)$$

$$v(I) = E(I^2) - E(I)^2$$

Based on Moran’s I statistics (I), z_i is the x-component value of the kebele “i” deviation from the mean value ($x_i - \bar{x}$). $w_{i,j}$ is the spatial weight between kebeles “i” and “j”, and n is the total number of kebeles (neighborhood units). s_o is the aggregate of all spatial weights. When the p -value is statistically significant, for the component with a positive or negative z-score, you may reject the null hypothesis.

LISA is used to assess local hotspots and the impact of individual locations on the magnitude of “Moran’s I” and to identify outliers [95]. A positive value for LISA indicates spatial clustering of similar values (either high or low values), and a negative value indicates spatial clustering of dissimilar values. In this paper, LISA examines the local-specific pattern of a given MDI component value that most strongly contributes to spatial inequality and poverty polarization. GeoDa software computed LISA and Moran’s I spatial statistics, considering the weight given for each “kebele,” or neighborhood unit, using queen contiguity weight. The LISA formula is specified as indicated below, based on Anselin (1995) [95].

$$I_i = z_i \sum_j w_{ij} z_j \quad (5)$$

Analogous to the global Moran’s I, the observation z_i , and z_j are in deviation from the mean. The summation over j is such that only neighboring values $j \in J_i$ are included. w_{ij} denotes weights, which may be in the row-standardized form or not. The weight w_{ij} is, by convention, equal to “0” [95,96]. A high-high (H-H) LISA relation indicates that a neighborhood with a significantly higher value is surrounded by neighborhoods with higher values, while a lower neighborhood value is surrounded by a lower neighborhood value for a LISA low-low (L-L) relation. A high-low (H-L) LISA relationship indicates that a neighborhood with a higher value is surrounded by neighborhoods with lower values, while a lower neighborhood value is surrounded by neighborhoods with higher neighborhood values for a low-high (L-H) relationship.

The PCA pattern is triangulated with the LISA pattern to augment the internal validity of the findings. The LISA interpretations were further synchronized with formal and informal settlement morphologies from a Quickbird image of 2009 (for MDI 2007) and a historical Google image from 2016 (for MDI 2016). In addition, our previous study and ground verifications of informal settlements enriched the interpretations of the overall findings. By interpreting low (LISA L-L) and high (LISA H-H) deprivation clusters, areas of polarization of poverty and spatial inequality were identified for each PCA component.

4. Results

4.1. PCA Result for MDI 2007

SPSS 20's correlation matrix identified 23 indicators or variables with significant correlations ($p < 0.05$). The overall collinearity was 5.108 (no-collinearity), exceeding the determinant threshold ($p > 0.00001$). The KMO was 0.842, which implied the sample size was sufficient to proceed with factor and PCA analysis. The BTS was significant ($p < 0.001$), and the Chi-square (X^2) was 3151.339 to reject the null hypothesis that the correlation matrix is uncorrelated. The communality for all 23 variables in the 2007 census was greater than 0.3. For further reference on indicators, components, and communalities, see Table 2. The communality (r^2), or percent of variance explained by the model, was >0.6 for all 23 indicators of the MDI 2007. The first, second, third, and fourth components explained 40.25%, 26.97%, 9.218%, and 4.783% of the variation in the original data set, respectively. The communality is >0.6 for all indicators and >0.89 for nine (9) indicators. See Table 2 for a further overview of the 4 components and 23 indicators.

Table 2. Rotated Component Matrix of PCA for 24 deprivation indicators and 4 components/factors based on the 2007 census for Addis Ababa City.

Indicators	Communality	Component 1	Component 2	Component 3	Component 4
		LHSS	HEPSV	VUSG	PHSC
Illiterate population	0.899	0.783		0.438	0.301
Degree-level education-deprived	0.763	0.826			
Wall-deprived	0.817	0.566	0.586	0.388	
Floor-deprived	0.930	0.928			
Ceiling-deprived	0.922	0.819	−0.484		
Aged houses	0.935	−0.321	0.703	0.566	
Deprived housing facilities	0.935	0.938			
Over crowdedness	0.855	0.305	0.85		
Population density	0.730		0.759		0.324
Own piped-water-deprived	0.667	0.809			
Sanitation-deprived	0.763	0.829			
Waste disposal-deprived	0.851	0.796	−0.427		
Modern cooking-deprived	0.869	0.886			
Electric-light-deprived	0.925	0.59	−0.520	0.359	0.411
Bathing facility proportion	0.598			−0.714	
Kitchen-deprived	0.788		0.376		0.786
Private tenure owner deprivations	0.919	−0.471	0.812		
Disabled population	0.349		0.484		
Migrant population	0.869	0.415		0.727	0.317
Widowed/divorced FHHs	0.889		0.670	0.620	
Unemployment	0.613		0.768		
Old dependency rate	0.890			0.897	
Young dependency rate	0.904	0.767	−0.530		

Component 1: It is named Low Human Capital and Substandard Services (LHSS), which is based on the strength of this component's indicators' loading scores and the direction of relationships. In generic form, the loading score (>0.76) is higher for three indicators describing low human capital asset proportions (higher illiteracy, deprivation of a high education level, and a higher proportion of young dependents). This component has a high loading score (>0.59) in generic form for substandard housing materials, poor housing facilities, poor services (sanitation, water, modern cooking), less electricity provision, and a low proportion of waste disposal services. In sum, this component's physical deprivation and low human capital are crucial aspects.

Component 2: It is named Health, Social, and Physical Vulnerability (HEPSV) based on the strength of the loading score (>0.48) for three indicators that contribute to public health deterioration (higher overcrowding, higher population density, and higher disability). The high loading score (>0.66) for the indicators (unemployment and FHH widows or divorced) demonstrates the area's social and economic vulnerability. The area's physical assets and private tenure ownership deprivations were implicated by the high loading score (>0.7) for indicators (old-aged houses and private tenure owner deprivations). HEPSV loading scores, on the other hand, describe a lower deprivation of electric light and waste disposal services (-0.4), which is typical in the inner-city area. The lower percentage of young dependents (-0.53) relative to other components means the area has an older population.

Component 3: It is named Vulnerable Social Groups (VUSG), primarily considering the high loading score (>0.72) for indicators of vulnerable groups (a higher proportion of old dependents and a higher proportion of migrants). VUSG's loading score (-0.71) explains the low percentage of bathing facilities. Furthermore, this component ranks second, relative to other components, regarding the proportion of FHH widows and divorced, illiterate HHs, aged houses, and lack of access to electricity.

Component 4: This component is known as "poor housing services and congestion" (PHSC) due to a high loading score (>0.4) of low physical capital assets (no specific kitchen room in the house and a high proportion of deprived electric lighting). It also indicated a high loading score (>0.3) for high population density next to the second component. The non-provision of electrical services is a peri-urban or fringe neighborhood settlement feature. This is due to the fact that the government did not install electricity on undeveloped land in accordance with the statutory plan. The deprivation of the kitchen reflects the features of inner-city slums and peri-urban informal settlements.

4.2. PCA Result for MDI 2016

For MDI 2016, the correlation matrix in SPSS 20 screened 11 variables with significant correlation ($p < 0.05$). The overall collinearity was 0.005, exceeding the determinant threshold ($p > 0.00001$). The KMO was 0.652, which assured that factorial analysis could proceed for MDI 2016. The BTS was significant ($p < 0.001$), and the Chi-square (X^2) was 461.879, significant enough to reject the null hypothesis that the correlation matrix is uncorrelated. The variations explained by the first, second, and third factors/components are 27.44%, 20.620%, and 11.87%, respectively. The communality for all MDI 2016 indicators is greater than 0.6. See Table 3 for a further overview of the three components and eleven indicators.

Component-1: It is named "Congested Living and Vulnerable Social Group (CLVS)" considering the high positive loading score for indicators of this component. The high loading score (>0.47) for widowed or divorced FHHs and unemployed HHs explains the high proportion of vulnerable groups. The high loading score (>0.58) for buildings and population density also signified substandard housing and a lack of living space for vulnerable groups. The overcrowded living conditions and concentration of vulnerable groups depicted Addis Ababa's inner-city areas.

Table 3. Rotated Component Matrix of PCA for 11 deprivation indicators and 3 components of MDI 2016.

Indicators	Communality	Component-1	Component-2	Component-3
		CLVS	LSES	EVIN
Illiterate HHs	0.687	0.299	0.703	0.323
Non-degree HHs	0.425	−0.312	0.572	−0.010
Self-employed HHs	0.600	−0.020	0.774	−0.024
Unemployed HHs	0.263	0.478	−0.168	−0.082
2016 income per AE	0.548	−0.096	−0.719	−0.147
Widowed/divorced FHHs	0.643	0.777	0.196	−0.027
Older HHs	0.607	0.779	0.009	0.018
Building density	0.781	0.660	0.232	−0.540
Population density	0.702	0.584	0.371	−0.473
Green per capita	0.807	0.012	0.097	0.893
Road per capita	0.906	−0.183	0.076	0.931

Component 2: This component is called “Low Socio-Economic Status (LSES)”. The higher positive loading scores (>0.57) for the percentage of non-degree HHs, illiterate HHs, and self-employed HHs are interwoven to form low human capital assets. On the contrary, there is an inverse relationship between low income (−0.719) and a high proportion of illiterate people (0.687), a low proportion of degree-level HHs (0.425), and a high proportion of low-paid self-employed jobs (0.6). As a result, low income and low human capital assets result in low socioeconomic status. The preceding statement indicates that low education leads to low-income and low-paid jobs that, in turn, enforce poverty traps for individual HHs and neighborhood HHs, which seeks further research on the negative neighborhood effects of poverty concentration.

Component 3: The component is named Environment and Infrastructure (EVIN) based on the high loading score for green space and roads per capita. The EVIN component revealed an inverse relationship between a high proportion of roads per capita (0.931) and green per capita (0.893) on the one hand and a low proportion of the population density (−0.473) and building density (−0.54) on the other hand. In general, the amount of green space and infrastructure per capita is low in overcrowded slum areas, while it is high in newly developed, formal suburban areas.

4.3. Computing Non-Standardized MDI (NSMDI) and Standardized MDI (SMDI)

The NSMDI and MDI were computed for MDI 2007 and MDI 2016. The four components of MDI 2007 and the three components of MDI 2016 explained the overall variation of 81.2 percent and 59.93 percent of the original datasets, respectively. The NSMDI and MDI were computed for 2007 and 2016 for components with Eigen values >1.

$$NSMDI_{2007} = \left(\frac{40.25}{81.22}\right) \times (f1) + \left(\frac{26.97}{81.22}\right) \times (f2) + \left(\frac{9.22}{81.22}\right) \times (f3) + \left(\frac{4.78}{81.22}\right) \times (f4)$$

$$NSMDI_{2016} = \left(\frac{27.44}{59.93}\right) \times (f1) + \left(\frac{20.62}{59.93}\right) \times (f2) + \left(\frac{11.87}{59.93}\right) \times (f3)$$

The MDI was computed for 2007 (MDI_{2007}) and 2016 (MDI_{2016}) based on the formula below.

$$MDI_{2007} = \left| \frac{(NSC - NLV)}{(NHV - NLV)} \right| \times 100 = \left| \frac{(NSC - (-1.8982))}{(1.3954 - (-1.8982))} \right| \times 100$$

$$MDI_{2016} = \left| \frac{(NSC - NLV)}{(NHV - NLV)} \right| \times 100 = \left| \frac{(NSC - (-1.3101))}{(1.5547 - (-1.3101))} \right| \times 100$$

4.4. The Overall Spatial Pattern of Deprivations Concentration

For the MDI 2007 classification, the most deprived quarters were pervasive in most parts of the city, while the intensity of deprivation was less for most of the intermediate areas. Yet, for the MDI 2016 classification, the most deprived areas showed vivid clustering

in the inner-city slums and peri-urban informal settlements, while the intermediate and formal suburban areas were less deprived quarters. See Figure 4 for MDI 2007 and MDI 2016 deprivation classifications.

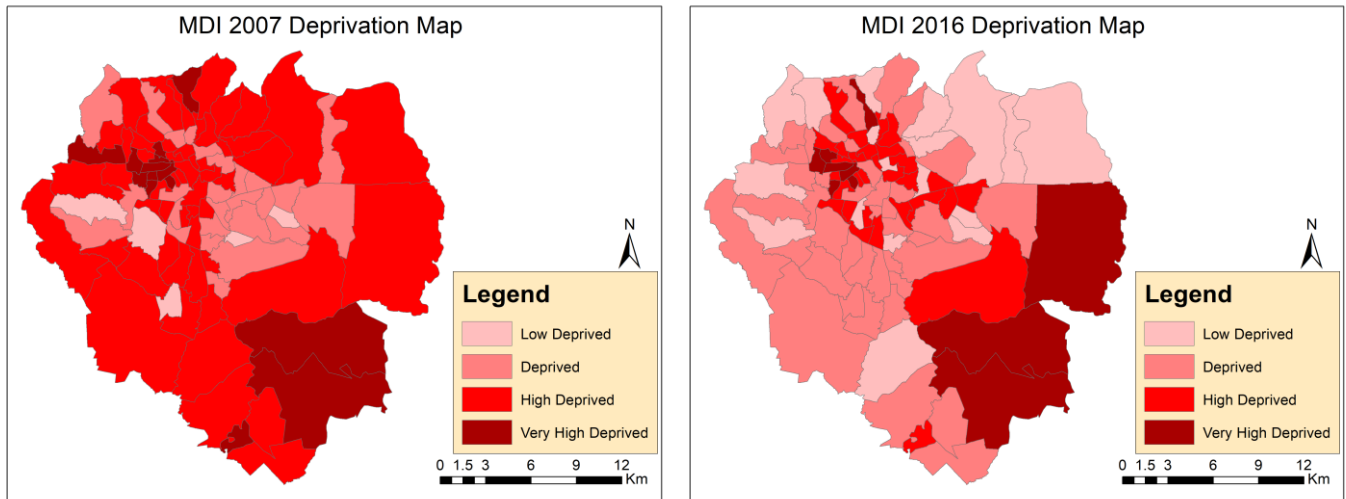


Figure 4. Deprivation classification for MDI 2007 and MDI 2016.

For components 2007 and 2016, the result of Moran’s I indicated significant positive spatial autocorrelation, while the strength of the “Moran’s I” coefficient was high for MDI 2007, relative to MDI 2016, due to the consideration of a multitude of census indicators. The global “Moran’s I” for MDI 2007 and MDI 2016 indicated that neighborhood units with high deprivation scores were close to each other, revealing the spillover effect of poverty concentration on adjacent neighborhoods. Component 2 (HEPSV) of the MDI 2007 demonstrated strong positive spatial autocorrelation, relative to other MDI 2007 components, justifying how the deterioration of public health and vulnerability formulated a concentrated poverty pattern and spatial inequality. For MDI 2016, Moran’s I result was positive and strong for component 3 (EVIN), compared to other MDI 2016 components, verifying how a lack of road infrastructure and green space per capita leads to a pattern of concentrated poverty. See Table 4 for the result of the global “Moran’s I” index.

Table 4. Moran’s index for components of MDI 2007 and MDI 2016.

Component (2007)	Component 1 (LHSS)	Component 2 (HEPSV)	Component 3 (VUSG)	Component-4 (PHSC)
Moran’s I (2007)	0.463	0.604	0.478	0.469
Component (2016)	Component-1 (CLVS)	Component-2 (LSES)	Component-3 (EVIN)	
Moran’s I (2016)	0.363	0.283	0.445	

4.4.1. The Local Spatial Pattern of Deprivations and Inequality for MDI 2007

The LISA H-H (red color) showed high deprivation in inner-city slums as well as informal settlements (peri-urban and suburban areas) for MDI 2007, while the blue color indicated low deprivation clusters (LISA L-L). The light blue on the LISA indicated low-high (L-H), while the light red indicated high-low (H-L).

MDI 2007 Component-1 (LHSS) spatial pattern

The LISA H-H relation indicated a high level of deprivation in the suburbs and peri-urban areas of the Bole and Akaki Kaliti sub-cities. In conjunction with this component PCA pattern, the high deprivation spatial pattern suggested a lack of durable housing materials, environmental services, and human capital assets in the outskirts informal settlements. Low deprivation was identified by the LISA L-L for areas that were dominated by formal settlements (the sub-city areas in the eastern parts of Chirkos, parts of Yeka, and the

northern part of Bole). Hence, the LISA L-L showed that the Arada sub-city, which served as Addis Ababa's former cultural and educational hub, had a low concentration of deprivations. Look at Figure 5 for a further overview.

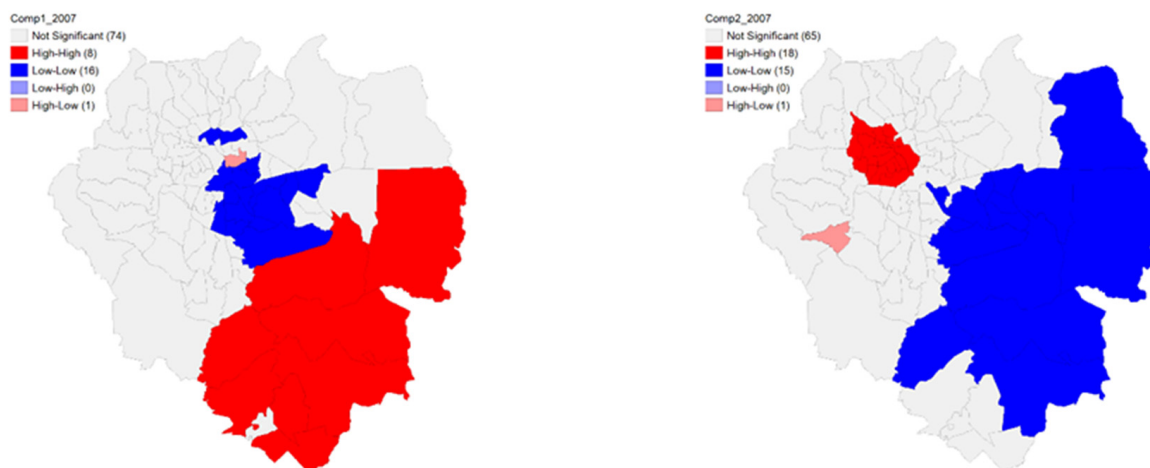


Figure 5. LISA cluster map for MDI 2007 component one [LHSS] on the left and component two [HEPSV] on the right.

MDI 2007 HEPSV (component-2) spatial pattern

The LISA H-H relationship revealed a high concentration of deprivation in inner-city slum areas. In line with the PCA result for this component, inner-city slums were severely deprived in terms of public health, housing deterioration, and socio-economic vulnerability. Following LISA H-H, the most deprived areas were the entire Addis Ketema sub-city (old CBD), the Lideta sub-city (except for the southwestern part), the western parts of Arada, and the southern parts of the Gulele sub-city. This component showed low deprivation concentration (LISA L-L relation) in the formal settlement-dominated sub-city areas of Yeka, Bole, Chirkos, and Akakai Kaliti. See Figure 5 for a further overview.

MDI 2007 VUSG (component-3) spatial pattern

The LISA H-H depicted high deprivation concentrations in peri-urban areas of the Akaki Kaliti sub-city, the inner-city slum areas of the Arada sub-city (except the western strip), and the central part of the Gulele sub-city. Considering the PCA analysis of component 3, the high clustering of deprivation was attributed to the high proportion of migrants who severely lacked electric and bath services, reflecting the character of peri-urban settlements. Furthermore, the high proportion of old dependents as well as the repository of recent migrants reflected the character of the inner-city slum areas. The western neighborhoods of Kolfe-Keranyo and Nifas Silk Sub-cities, as well as strip areas of Bole sub-city, were the low-deprivation concentration areas for VUSG, mainly consisting of formal settlement areas. See Figure 6 for a further overview.

MDI 2007 PHSC (component-4) spatial pattern

The LISA H-H showed that deprivation of kitchens and electricity was the main pattern for the undeveloped areas in the peri-urban informal settlement areas of Bole and Akakai Kaliti sub-cities, as well as the inner-city slum areas of the Chirkos sub-city (the central part), Arada sub-city (the western part), and Lideta sub-city (the northern part). On the other hand, the northern suburban areas of Addis Ababa, especially the expansive mixed settlement areas of Gulele and Kolfe-Keranyo sub-cities, were the sites of LISA L-L clustering. See Figure 6 for a further overview.

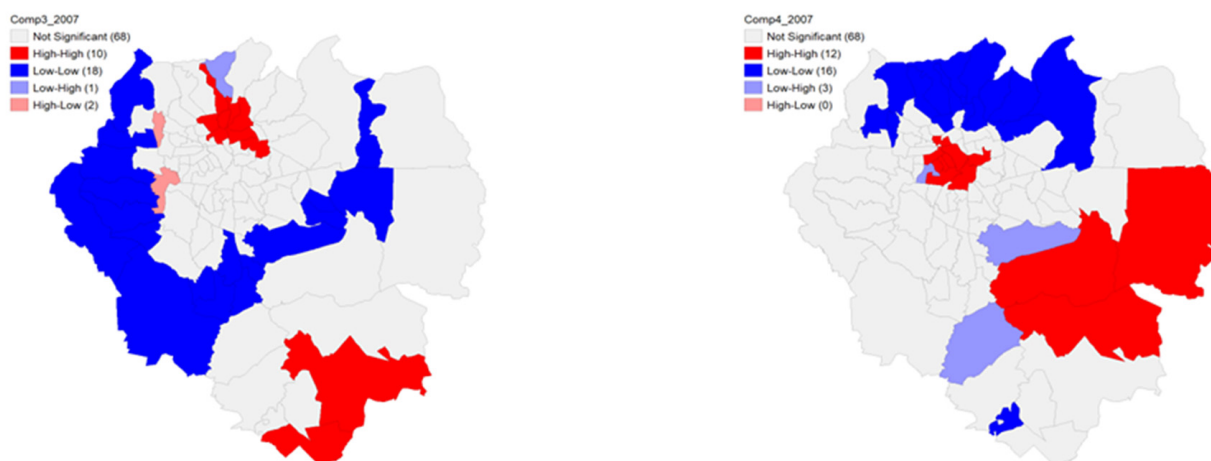


Figure 6. LISA cluster map for MDI 2007 component 3 [VUSG] on the left and component 4 [PHSC] on the right.

4.4.2. The Local Spatial Pattern of Deprivations and Inequality for MDI 2016

MDI 2016 CLVS (component 1) spatial pattern

The LISA H-H relation for this component depicted a high deprivation concentration in the purely inner-city slum areas of Lideta and Addis Ketema sub-cities. The low-density settlement parts, in the peripheral mixed neighborhood areas of the Kolfe-Keranyo sub-city (west) and the formal settlement areas of the Bole and Yeka sub-cities, showed areas of LISA L-L relation. In conjunction with the PCA result of this component, vulnerable social groups and congested living conditions were characteristics of the inner-city slum, while they were less prevalent in formal neighborhoods. See Figure 7 for a further review.

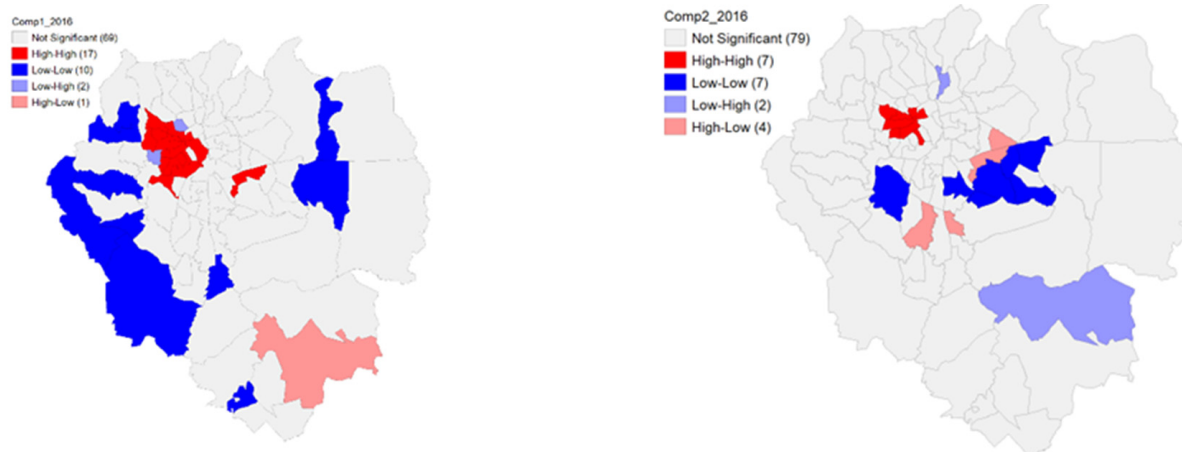


Figure 7. LISA cluster map for MDI 2016 component 1 [CLVS] on the left and component 2 [LSES] on the right.

MDI 2016 LSES (component 2)

The LISA-H-H showed high deprivation concentrations in the inner-city slum areas of the Addis Ketema sub-city, the northern part of the Lideta sub-city, and the western part of the Arada sub-city. The LISA L-L showed clustering in the formal settlement neighborhoods in the north-central part of the Bole sub-city and a single formal neighborhood for each of the Chirkos and Nifas Silk sub-cities. Concerning the PCA findings of this component, the concentration of deprived human and financial capital assets was one of the features of the inner-city slums, while the intermediate formal areas were concentration areas for dwellers with high socioeconomic status, explaining why poverty was less polarized in formal neighborhoods. See Figure 7 for a further review.

MDI 2016 EVIN (component 3)

Based on the LISA H-H relationship, green and road space per capita showed high clustering in the intermediate and suburban areas of the Akaki Kaliti and Bole sub-cities. The aforementioned areas were newly developed formal areas with major road extensions for development; however, they consisted of sparse settlers in 2016. On the contrary, the inner-city slum sub-cities such as the Addis Ketema sub-city, Arada sub-city (the major parts), and Lideta sub-city (the northern part) showed LISA L-L clustering, explaining the lower proportion of green space and road infrastructure per capita for the inner-city slum areas. See Figure 8 for a further overview.

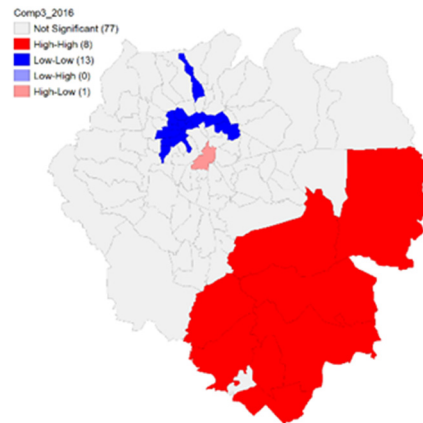


Figure 8. LISA cluster map for MDI 2016 component 3 [EVIN].

4.5. Population Proportion versus MDI

4.5.1. MDI Classification versus Deprived Population Proportion MDI 2007

The Addis Ketema sub-city had 81.1% of the VHD population, followed by the Lideta sub-city (27.8%). For the three sub-cities (Akaki Kaliti, Kolfe Keranyo, and Gulele), 10–15 percent of the population belongs to the VHD category. In the Akaki Kaliti sub-city, 85.3% of the population belongs to the HD category. HD populations ranged from 19 to 78% in Yeka, Gulele, Nifas Silk, Arada, Chirkos, Kolfe Keranyo, Lideta, and Addis Ketema sub-cities. Every Addis Ababa sub-city had at least one kebele that belonged to the HD or VHD group. See Figure 9.

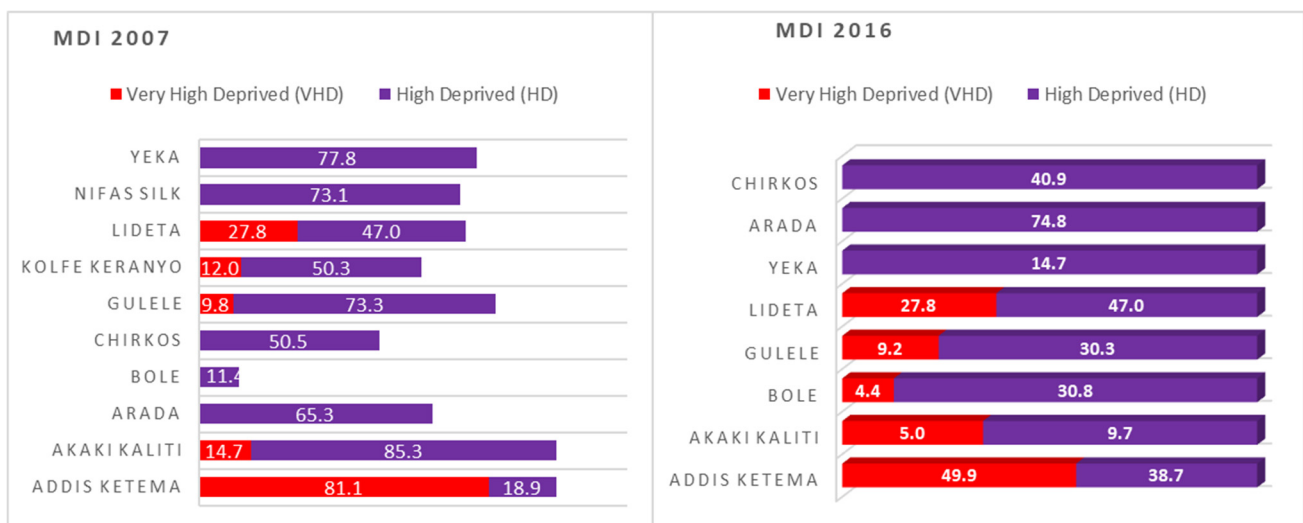


Figure 9. Very high-deprived (VHD) and high-deprived (HD) population percent for AA (Addis Ababa) sub-cities based on MDI 2007 and MDI 2016.

4.5.2. MDI Classification versus Deprived Population Proportion (MDI 2016)

Sub-cities of Addis Ketema and Lideta accounted for 49.9% and 27.8% of the VHD population, respectively. For Gulele, Akaki Kaliti, and Bole sub-cities, less than 10 percent of the population belongs to the VHD category. The Arada sub-city constituted 74.84% of the HD population. The other sub-cities of Addis Ababa (excluding Nifas Silk and Kolfe Keranyo) comprised 10–47% of the HD population. Sub-cities, such as Kolfe Keranyo and Nifas Silk, do not have a population that belongs to the VHD and HD categories.

4.5.3. MDI 2007 and MDI 2016 Comparative Assessment

The most deprived (VHD and HD) population constituted 68.6% and 33.0% of the MDI in 2007 and 2016, respectively. Deprivations have shown declining trends from MDI 2007 to MDI 2016, despite different indicators used for MDI construction. Nonetheless, more research into concentrated poverty, relating deprivation to population density, migration trends, and other factors, is crucial due to the increasing trends in the urbanization of poverty. Compared to MDI 2007, the MDI 2016 population proportion that belongs to HD declined for the sub-cities of Gulele, Akaki Kaliti, Chirkos, and Yeka (sharp decline). The Lideta sub-city population that belongs to HD remained similar in the intervening MDI periods. The Arada sub-city population proportion that belongs to HD increased for MDI 2016 relative to MDI 2007. For MDI 2007, the Kolfe Keranyo sub-city represented 7.1% and 50.3% of the VHD and HD populations, respectively. Nonetheless, for MDI 2016, 0% of the Kolfe Keranyo population has VHD or HD.

4.6. *The Spatial Trend of Population Density versus MDI*

The MDI 2007 and MDI 2016 graphs showed that deprivation peaks in the CBD area and then declines gradually with a noticeable drop in the intermediate city, then rises again until it reaches the equivalent of the CBD peak in the peri-urban area of Addis Ababa and then declines again towards the rural areas.

For MDI 2007, the deprivation score shows a progressive decline until a high peak at 2 km from the CBD, and then again increases to reach a small peak at about 4 km. Then, deprivation showed a recognizable decline at about 5–9 km from the CBD, rose again, roughly equivalent to the CBD in peri-urban areas, and then declined towards the rural areas outside Addis Ababa's peri-urban area. For MDI 2016, the deprivation score showed a sharp decline at 6 km from the CBD, an increase again from 6–7 km from the CBD, and a steady decline from 7–10 km from the CBD. Then, MDI 2016 illustrated a progressive increase to reach a peak equivalent to the CBD around the peri-urban area of the city. Again, MDI 2016 showed a progressive decline in the pure rural area outside Addis Ababa's peri-urban area.

The graph illustrated that the deprivation extent in the inner-city slum is consolidating and expanding since a sharp decline occurred at 2 km from the CBD for the MDI 2007, while the sharp decline was at about 5–6 km from the CBD for the MDI 2016. The population density declined sharply from the CBD, with two recognizable peaks at about 0.5–1 km and 2–4 km and a progressive decline (6–20 km) towards the outskirts of the city for the two MDI periods. The general trends for the two MDI periods revealed that deprivation score and population density had more or less direct correspondence in and around the CBD. However, as one moves from the center of the city to the peri-urban areas, deprivation rises with the progressive drop in population density. The urban form and location, whether it is a formal or informal settlement, influence the spatial concentration of deprivations. The PPMC between MDI 2007 and population density was 0.379. The PPMC between MDI 2016 and population density was 0.497. Based on the findings, deprivation has recently increased in direct proportion to population density, revealing the increasing trends of concentrated poverty in the slums of Addis Ababa (Figure 10).

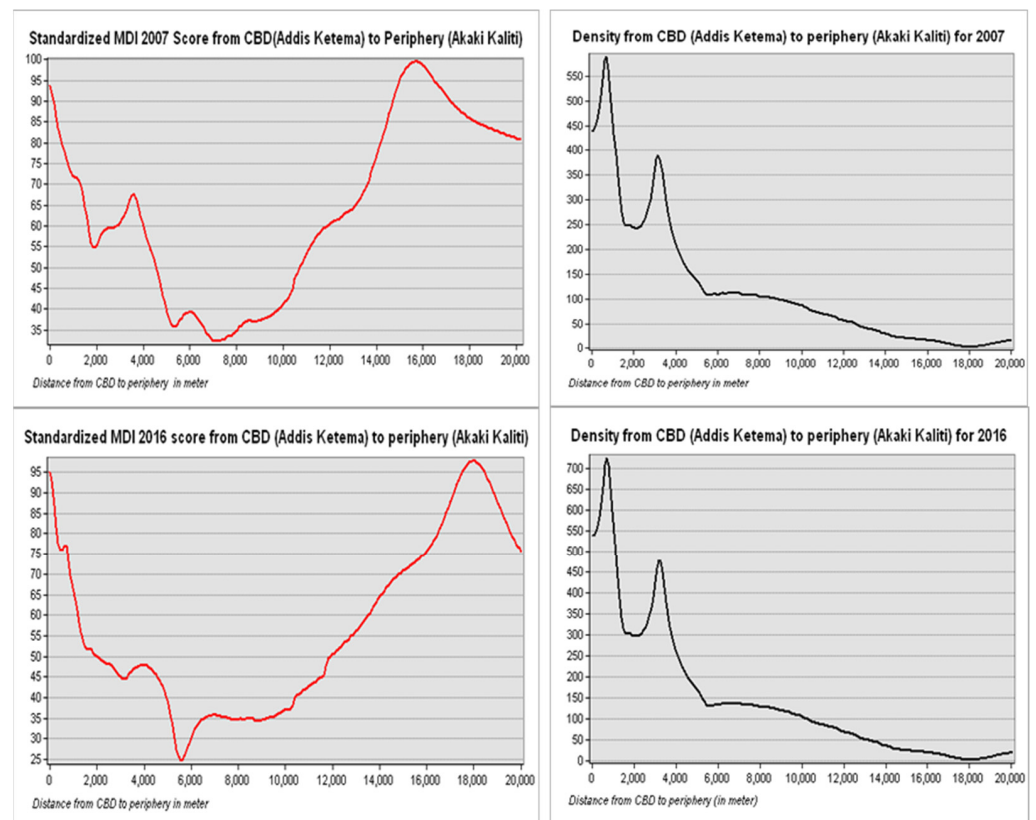


Figure 10. The cross-section of deprivation standardized score and population density of Addis Ababa city from the old CBD (Addis Ketema) towards the periphery (Akaki Kaliti sub-city).

5. Discussion

5.1. Overview of MDI 2007 and MDI 2016: Inductively-Derived PCA Analysis and Spatial Pattern

The MDI 2007 and the MDI 2016 discussed the findings of the first and second research questions in combination by triangulating the pattern of PCA-derived indicators and components with the pattern obtained from the spatial pattern of components. The study also triangulates the findings with SDG, theoretical, and empirical frameworks. For MDI 2007, the result indicated that the first and second components were the main ones, constituting 67.2 percent of the variations in the original dataset, while the third and fourth components explained only 14 percent. For MDI 2016, three of the components explained 60% of the variation in the original data set, with no drastic differences in the percentage of variance explained by the three components. The MDI 2007 and MDI 2016 developments indicate that poverty is multidimensional and multifaceted [61,63,64]. The persistence of low education levels and a high proportion of illiterate HHs as a critical component of the MDI in 2007 and 2016 implied that much work needed to be done to improve informal parental education as well as the overall quality of education to reduce the negative and transgenerational effects of poverty traps [28]. Education level is associated with income, housing inadequacy, unemployment or poorly paid jobs, and poor infrastructure, which rationalizes achieving sustainable urbanization by linking SDG goals 1, 4, 8, and 11. The MDI 2007 and 2016 both revealed a link between vulnerability and deprivation [67–71], implying that the MDI should be used to target resources, green space, and infrastructure to socially excluded and vulnerable groups in order to meet SDGs 1 and 11.

Deprivation is associated with the urban form of Ethiopia, as it is higher in declining inner-city and peri-urban informal settlements while it is lower in intermediate and suburban planned and new development regions [41]. The overlaps of correlated indicators and components over space using PCA and the facts of spatial inequality based

on spatial autocorrelation analysis reinforce the necessity of place-based compensatory policy [25,27,28,44–46]. An area-based policy is justified for Addis Ababa due to a high annual rate of urbanization, a divided city, informal settlement problems, and a housing supply shortage [11,12,25,36,47]. The MDI is helpful for tracking the indicators and extent of problems related to SDG 11's housing inadequacy [14,59], based on the findings of the 2007 MDI.

5.1.1. MDI 2007 Component 1 (LHSS): PCA and Spatial Pattern Analysis

This component explained the overlaps and coexistence of a high proportion of sub-standard housing materials and limited access to services (water, sanitation, waste disposal, cooking, and electricity). In addition, this component also explained inadequate housing facilities and low human capital assets (low educational status, high illiteracy, and a higher number of young dependents). In sum, this component reflected the most pervasive problems common to large parts of Addis Ababa's informal settlements. Because of the dominance of substandard housing, poor services, and facilities, the use of MDI for urban regeneration and prioritization [50,52,53] is rationalized. Therefore, there should be a trend to capture a multitude of problems rather than focusing on some specific criteria not supported by MDI tools, learning from Addis Ababa's slum upgrading experience [48]. The higher proportion of people with lower education and young dependents reflects the typical character of the Ethiopian poor [18]. Yet, the relatively lower electricity provision for this component (LHSS) relative to the second component (HEPSV) indicates that this component reflects the largely suburban and peri-urban informal settlement features. Deprivation is concentrated, based on the LISA H-H relation, in the outskirts, central, and southern suburban informal settlements. Therefore, this component reflected the features of informal settlements outside the inner-city slum.

Yet, the L-L relationship of LISA is depicted in some neighborhoods of the old cultural and education center (piazza) established by the Italian colony (Arada sub-city) and modern formal settlement neighborhood units in the sub-cities of Bole, Chirkos, and Yeka. The SDG 11 housing inadequacy indicators (poor sanitation service, poor water service, and poor housing durability) had a high loading score for this component; therefore, the housing inadequacy indicator of the SDG reflected most of the Addis Ababa informal settlements [29]. In addition to the SDG slum indicators, high-loading score indicators such as low educational capital assets and deficient housing facilities are potential indicators for informal settlements. Because poor education and inadequate housing are overlapping indicators, it makes sense to combine SDGs 4 and 11 for addressing human and physical capital asset deprivation.

5.1.2. MDI 2007 Component 2 (HEPSV) PCA Analysis and Spatial Pattern

This component has a strong positive global spatial autocorrelation, explaining that the inner-city slum is an area of concentrated and polarized poverty. This component showed overlaps and coexistence of a high proportion of older housing, deprived private tenure rights (renters), overcrowded living, a dense population, a high proportion of disabilities, and the unemployed. Based on the above fact, this component witnessed the clustering of the most vulnerable dwellers and renters living in aging dwellings. On the contrary, most houses had a high proportion of electricity and waste disposal services [80] due to their inner-city location. The characteristic of a high proportion of old buildings, degenerating housing and infrastructure, and the most vulnerable sub-group, reflects the typical inner-city slum features [23,31,36,74]. The SDG indicators (overcrowding and private tenure owner deprivations) had a higher loading score for this component, which reinforces the inner-city slum nature of this component [23,31,74]. For this component, a high proportion of renters, older houses, and substandard dwellings justify the preponderance of dilapidated and old kebele and municipal rental dwellings in inner-city slums [31].

In addition, the MDI 2007 component 2 (HEPSV) has high positive loading scores for the widowed or divorced FHHs and disabled population proportions. The above result ex-

plained the association of multiple deprivation indicators with the concentration of socially excluded and vulnerable groups [68–70]. Moreover, the concentration of FHH widows or divorcees in the urban core, in line with social organization theory [69], implicates the necessity of gender and marital status mainstreaming interventions. The high proportion of unemployed people in the inner-city slum indicates the economically vulnerable subgroups were the most exposed to multiple deprivations [67]. The spatial pattern based on the LISA map confirmed that the high deprivation area is concentrated in the inner-city slum areas, aligning with the inductively derived and discussed PCA pattern for characterizing inner-city slums. Low-deprivation areas were concentrated in the suburban formal settlement sub-city areas.

5.1.3. MDI 2007 Component 3 (VUSG) PCA Analysis and Spatial Pattern

This component revealed the coexistence of vulnerable groups (old dependents, migrants, widowed or divorced FHHs, illiterate), aged buildings, substandard housing walls, less access to electricity, and bathing facilities. This component indicator partly reflects inner-city slum characteristics (old dependents, aged buildings, vulnerable female HHs, and substandard housing materials). In addition, this component indicates characteristics of informal settlements outside the inner-city slum (a high proportion of migrants, a lack of electric services, and substandard housing materials). Similarly, the LISA H-H pattern revealed deprivation clustering in inner-city slums and peri-urban areas. The peri-urban informal or squatter settlements are the main repository for rural-urban migrants [8,31,34,79] and are furnished with little or no electricity. Furthermore, the LISA revealed a high concentration of deprivation in inner-city areas, reflecting the repository of migrants, old buildings, and vulnerable groups in the inner-city areas. The empirical frameworks also mentioned the existence of inner-city squatters in Addis Ababa [31,35], who are mainly migrants. Additionally, a sizable portion of slum residents who resided close to the old CBD rented beds [34] in crowded rooms for temporary and recent migrants.

5.1.4. MDI 2007 Component 4 (PHSC) PCA Analysis and Spatial Pattern

This component reflected houses deprived of kitchens in informal settlements due to space shortages for separate kitchens as well as areas deprived of electricity. According to the spatial pattern depicted by the LISA H-H relation, this component showed high deprivation clustering in the inner-city slum areas and the southern and eastern fringe informal settlement areas of Addis Ababa. Yet, the LISA L-L clustering was depicted in the northern and western mixed (formal and informal) settlement areas of Addis Ababa. Based on our 2018 Addis Ababa case study area survey, 60% and 40% of the selected peri-urban and inner-city slum areas do not have kitchens, respectively.

5.1.5. MDI 2016 Component 1 (CLVS) PCA Analysis and Spatial Pattern

This component indicated the reinforcing and overlapping nature of deprivations based on indicators of high population density, high building density, widowed or divorced FHHs, older HHs, and unemployed HHs. The first component indicated the overcrowded living conditions of vulnerable sub-groups. The findings implicate that Addis Ababa's inner-city slums are characterized by the area of concentration of the most vulnerable sub-groups living in overcrowded conditions [23,36,74]. Similarly, the spatial pattern of LISA H-H clustering revealed that the vulnerable social groups with high overcrowding were clustered in purely inner-city slum areas. The LISA L-L clustering was depicted in the peripheral mixed-settlement neighborhoods in the western fringe areas and the new formal settlement development areas of Addis Ababa.

5.1.6. MDI 2016 Component 2 (LSES) PCA Analysis and Spatial Pattern

The second component of MDI 2016 (LSES) explains how low income reinforces low human capital assets (high proportion of HH illiteracy, low higher education level, and low-paying self-employed jobs). The above finding justifies the link between SDGs 1, 4,

and 8. This is due to education being a means to reduce poverty by increasing people's income [15] and providing employment opportunities. The finding also implies that economic vulnerability reinforces multiple deprivations [65,67]. The PCA findings implicate the rationality of developing MDI from monetary and non-monetary indicators [65,66] since they are mutually reinforcing each other. The LISA H-H revealed how low socio-economic status and deprivation were created due to low human and financial capital assets. Because of the LISA L-L relationship, deprivation showed low clustering in formal neighborhoods, where most dwellers have high socioeconomic status.

5.1.7. MDI 2016 Component 3 (EVIN) PCA Analysis and Spatial Pattern

This component indicates that overcrowded places, in terms of population and building density, are less endowed with green and road infrastructure per capita. The above result conformed to the finding that slums in Addis Ababa are places disengaged from infrastructure and public space/greenery [23,36,74]. Yet, the less crowded areas, which are better endowed with green space and road infrastructure, are a feature of Addis Ababa's less developed outskirts. The result also justified the rationality of SDG target 11.7 for providing access to green and public open spaces for vulnerable groups [29]. Additionally, morphological characteristics extracted from satellite images are powerful indicators of deprivation [72,73].

5.2. Population Proportion and Density versus Deprivation

In line with the third and fourth research questions, the study analyzes and interprets the proportion of the most deprived population for MDI 2007 and MDI 2016, the correlations and spatial relationships between deprivation and population density, and then suggests the implications for area-based policy. The most deprived populations of Addis Ababa were 68% for MDI 2007 and 33% for MDI 2016. Deprivations have shown declining trends in most sub-cities; however, the inner-city slum sub-cities of Addis Ketema and Lideta remained in VHD for MDI 2007 and MDI 2016 as well. Similarly, HD also declined in proportion for most sub-cities, except for the inner-city slum sub-cities of Lideta and Arada. For the Kolfe Keranyo sub-city, the most deprived population declined from 62% for MDI 2007 to 0% for MDI 2016. The decline is due to the new, formal-dominated settlement that emerged over the course of the two MDI years.

Other than population proportion, other aspects of urbanization, such as migration and population density, explained concentrated poverty. Regarding density, the PPMC results explicitly indicated that deprivation increased with increasing population density, and the result justified how the density of the poor population definition describes concentrated poverty [37]. In addition, there is a spatial relationship between deprivations, population density, and urban form. For MDI 2007 and MDI 2016, deprivation reaches a peak in the old CBD area, with a progressive decline in the intermediate areas and rising again in the peri-urban area. In the old CBD area, population density increased along with the deprivation score for MDI 2007 and MDI 2016. Based on the spatial profile trends, the high deprivation score and population density near and around the old CBD align with the inner-city radius of 4.5 km from the main CBD [33]. In peri-urban areas, deprivation increased as population density decreased. The spatial profile indicated how deprivation trends varied with the Ethiopian urban form [41], as well as a vivid picture of deprivation polarization and a divided city pattern and the rationales for implementing area-based policy [25]. The threshold area of deprivation in the CBD expanded for MDI 2016, relative to MDI 2007, substantiating the overcrowding and consolidation of the inner-city slum population and density [32,33].

The high deprivation score in the peri-urban area conforms to Alonso's "bid rent model", which suggests that the poor housing and buildings lie in the affordable outskirts area [39]. The increasing deprivation in the fringe area, based on the deprivation profile graph, aligns with Addis Ababa's peri-urban informal settlement characteristics and locations [8,31,34,79]. Even if the old CBD of the inner city's large population concentration

replicated Alonso's "bid rent" model [40], the inner city is a repository of poor populations living in dense quarters. Deprivations increased with increasing rural-urban migrants in peri-urban areas [8,9,34,80], as well as consolidated, partly through bed rent and illegal squatting of migrants, in inner-city slums [34,35]. The findings indicated that the old inner-city slum of Addis Ababa is a concentrated poverty area that conforms to the global north theoretical lens [38]. Nonetheless, with the exception of some areas affected by renewal interventions [76], Addis Ababa's inner-city slum was not affected by the global north's deindustrialization and suburbanization of urban jobs [38].

The relationship between the spatial distribution of deprivation and population size and density rationalized the development of tools for better targeting concentrated poverty. The MDI is rational for better targeting and prioritizing since sector-based pro-poor spending does not fully benefit the vulnerable and poor population, based on the evaluation of 122 World Bank poverty-targeted social programs [42]. Moreover, the high proportion of vulnerable people, including elders, persons with disabilities, females, and the unemployed, implicated a policy framework and tools for better targeting and budget rationing for people needing social protection to realize SDG 1 [29,30]. In summary, a disaggregated area-based welfare policy is an essential intervention [5,44,49,59] to benefit the disadvantaged and vulnerable population and decrease the polarization of poverty.

6. Conclusions and Recommendations

Addis Ababa has highly accelerated population growth, largely owing to the high rates of net in-migration from both rural and urban areas, which leads to urban inequality, a divided city, and an escalated housing crisis. If the current high urbanization trend continues, Ethiopia's level of urbanization will constitute more than one-third of the total population before 2035. Nonetheless, urbanization in Ethiopia does not correspond to economic development, which is challenged by environmental hazards, housing inadequacy, poverty, unemployment, and informal settlements. Thus, inclusive cities and sustainable urbanization can be realized through appropriate regularity instruments and tools that tackle concentrated poverty, social exclusion, and spatial inequality.

The research developed the MDI, substantiated the overlaps of problems using indicators, and revealed the spatial pattern of inequality. The study also indicated the disproportional deprivation of large and vulnerable populations by analyzing deprivation versus population size and density. Then, the research suggested the justification for area-based policy based on the findings synthesized in line with the research questions. The overall spatial and statistical analysis indicated the multiple deprivations faced by the urban poor and the deepening spatial and social inequality. MDI tools help to locate and prioritize the poorest of the poor in the endeavor to meet SDG 10 on inequality. Hence, MDI measures the deprivations of sustainable livelihood capital assets suffered by the poor.

By combining PCA indicators and factors with SDGs and conceptual frameworks, the MDI indicators and factors are aligned with the external context to keep track of SDG targets and offer future directions for achieving the SDG. Moran's I and LISA revealed the overall and local spatial pattern of components and enriched the findings of PCA, determining whether the stated problems overlapped in space as well as with the triangulated deductive frameworks. The Morans' I-positive index, based on the coefficients of all components of the MDI in 2007 and 2016, is statistically significant enough to infer concentrated poverty. The LISA spatial pattern indicated a poverty or deprivation polarization between formal and informal settlements. The validation of PCA indicators and components with the LISA pattern revealed spatial inequality as well as the area where deprivation occurred in relation to specific components and indicators. The MDI, a composite index used in the study, is a tool for resource allocation, compensatory policy, and urban upgrading or redevelopment. Hence, the MDI illustrates the many deprivations that the urban poor experience.

In generic form, poor education, income, vulnerability, congestion, non-durable housing, poor services and infrastructure, and poor green access are the critical indicators that overlap in space, explaining the various forms of deprivation faced by the urban poor

between MDI 2007 and 2016. Thus, the above result suggests that integration among most of the SDG's targets should be achieved in tandem to address multiple deprivation issues while also reducing the transgenerational impact of poverty traps. The study suggested additional strong indicators of slums in addition to what is stated in the SDG. For both the MDI 2007 and 2016, low educational attainment and the concentration of vulnerable groups are strong indicators of deprivation in inner-city slum areas.

The most pervasive deprivation problems are deprivations of human capital, sub-standard housing materials, and poor services, as articulated in MDI 2007 component 1. Therefore, urban regeneration interventions shall be supported by consistent sustainable livelihood capital asset accumulation for the deprived to address most of the SDG's targets in an integrated manner. The triangulation of indicators based on these study findings and the SDG confirmed that Addis Ababa's issues are in sync with globally agreed indicators. For instance, the most pervasive problems, based on MDI 2007 component 1, such as non-durable housing materials, poor sanitation services, and poor water services, conform to the housing inadequacy indicators of SDG 11. The MDI 2007 component 2 indicators of overcrowding and deprivation of own tenure rights (a high proportion of renters) conform to SDG 11 housing inadequacy indicators. In addition to the housing inadequacy indicators aligned with SDG 11, MDI 2007 component 2 reflected general problems of social and economic vulnerability, social exclusion, and poor living conditions. A key strategic intervention is to incrementally upgrade tenure from kebele renter status or no tenure rights to de jure tenure rights, backed with livelihood capital asset accumulation and consolidation. Tenure security is a strategic intervention due to the fact that insecure residents are vulnerable to social exclusion, eviction, and the loss of physical capital asset accumulation.

Based on the assessment of MDI 2016 components 1 and 3, the urban regeneration interventions shall provide adequate open space, green space, and infrastructure access for social, economic, and health-vulnerable groups in slums and informal settlements to meet SDG 11 target 11.7. Furthermore, for the MDI 2016 components, the relationship between indicators of building density, green space, and vulnerable social groups implicates morphological features from satellite images as indicators of deprivation. Based on MDI 2016 component 2, low financial capital and low human capital assets (poor education and low-paying jobs) are reinforcing each other, which justifies the link between SDG 1 on poverty, SDG 4 on education, and SDG 8 on employment opportunity. The above link is justified because the lack of one of the indicators may expose the poor to other forms of deprivation and trigger a vicious circle of poverty. Because the two aspects are mutually reinforcing, MDI development must consider both financial and non-financial components.

Despite Addis Ababa's large number of deprived people in informal settlements, general deprivation trends show a downward trend. Deprivation, however, is polarized in slums and suburban informal settlements. The densely populated inner-city slum sub-cities are in a state of deprivation, exacerbated by inner-city consolidation, illegal building additions, and the repository of recent migrants. In addition, there is an exodus of rural-urban migrants who settled in peri-urban areas despite being faced with sporadic coercive bulldozing. The concentration of deprivation and population density in the inner-city slum, as well as the association of deprivation with less densely populated areas of the peri-urban zone, provided a spatial profile and trend regarding where the disadvantaged people were located. This would help to prioritize area-based targeting of beneficiaries or people who needed social protection or strategic planning interventions. Thus, compensatory budget allocation for small, disaggregated neighborhood units (kebeles) makes the budget reach the poor and vulnerable efficiently and effectively. The justification is that sector-based programs, rather than small area-based targets, obscure the unprivileged, socially excluded, and underclass populations. Furthermore, in a sector-based program, the benefits trickle down to the wealthy and other unintended target groups.

In Ethiopia, the postponement of the planned census in 2018 due to social unrest limited the ability to compare the MDI using similar indicators and forecast future trends in deprivation. Nonetheless, deprivation has been studied recently by researchers interpreting

morphology from cost-effective high-resolution images and sometimes in combination with other socio-economic information. The MDI 2016 development, integrating the survey conducted by the CSA every 5 years with other information, is one option for preparing a cost-effective and time-efficient MDI. The MDI is a composite tool that integrates data from various sources into usable information, including censuses, government surveys, base maps, remote sensing imagery, and so on.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su15031934/s1>, Table S1: AA_census_2007_PCA_Rotated_Matrix and AA_SEPlanning_2016_PCA_Rotated_Matrix. Table S2: AAMDI_2007 and AAMDI_2016 shape file (GIS format). Table S3: MDICensus_2007_SPSS_Principalcomponentanalysis and MDISEPLA_2016_SPSS_Principalcomponentanalysis (in sav file SPSS 20). Table S4: Rotated_Component_Matrix_2007 and Rotated_Component_Matrix_2016 (pdf format). Table S5: MDI 2007 LISA Analysis: MDI 2007 Component 1, 2,3, and 4 cluster, significance, and Moran’s I analysis. Table S6: MDI 2016 LISA analysis: MDI 2016 component1,2 and 3 cluster, significance and Moran’s I analysis. Table S7: Queen contiguity weight file using geoda software: MDI_2007_Lisweightcomp.gal and MDI_2016_Lisweightcomp.gal. Table S8: MDI2007_deprivationmap and MDI2016_deprivationmap(png format).

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References

1. UNDESA and World Bank Group. *Sustainable Development Goal 10—Reduced Inequalities: Progress and Prospects*; UNDESA and World Bank Group: Geneva, Switzerland, 2019.
2. Shifa, M.; Leibbrandt, M. *Spatial Inequality in Sub-Saharan Africa*; African Center of Excellence for Inequality Research (ACEIR) Working Paper Series; African Center of Excellence for Inequality Research (ACEIR): Cape Town, South Africa, 2021; pp. 1–45.
3. Ministry of Finance and Economic Development (MOFED). *Development and Poverty in Ethiopia 1995/96-2010/11 ETC*; Ministry of Finance and Economic Development: Addis Ababa, Ethiopia, 2013.
4. National Planning Commission (NPC). *Ethiopia’s Progress towards Eradicating Poverty: An Interim Report on 2015/16 Poverty Analysis Study*; National Planning Commission: Addis Ababa, Ethiopia, 2017.
5. Debebe, S.; Zekarias, E.H. Analysis of poverty, income inequality and their effects on food security in southern Ethiopia. *Agric. Food Secur.* **2020**, *9*, 16. [[CrossRef](#)]
6. Wolde, M.; Sera, L.; Merra, T.M. Causal relationship between income inequality and economic growth in Ethiopia. *Cogent Econ. Finance* **2022**, *10*, 2087299. [[CrossRef](#)]
7. Sulemana, I.; Nketiah-Amponsah, E.-A.; Codjoe, E.A.; Akua, J.; Andoh, N. Urbanization and Income inequality in Sub-Saharan Africa. *Sustain. Cities Soc.* **2019**, *48*, 101544. [[CrossRef](#)]
8. Bundervoet, T. *Internal Migration in Ethiopia Evidence from a Quantitative and Qualitative Research Study*; World Bank: Washington, DC, USA, 2018; Available online: <https://openknowledge.worldbank.org/handle/10986/32097> (accessed on 12 September 2021).
9. Central Statistics Agency (Ethiopia). *Ethiopian 2021 Labor Force and Migration Survey Key Findings*; Central Statistics Agency: Addis Ababa, Ethiopia, 2021.

10. Koroso, N.H.; Lengoiboni, M.; Zevenbergen, J.A. Urbanization and urban land use efficiency: Evidence from regional and Addis Ababa Sattelite Cities, Ethiopia. *Habitat Int.* **2021**, *117*, 102437. [CrossRef]
11. Ministry of Urban Development and Housing (MUDH). *National Urban Development Spatial Plan*; Egis International in association with IAU-IDF & Urban Lyon: Addis Ababa, Ethiopia, 2015.
12. World Bank Group and Cities Alliance. *Ethiopian Urbanization Review: Urban Institutions for Middle-Income Ethiopia*; World Bank: Addis Ababa, Ethiopia, 2015.
13. World Bank Group. Ethiopia Poverty Assessment: Poverty Rate Declines, Despite Challenges. 2020. Available online: <https://www.worldbank.org/en/country/ethiopia/publication/ethiopia-poverty-assessment-poverty-rate-declines-despite-challenges> (accessed on 5 October 2022).
14. SDG Tracker. Sustainable Development Goal 11. Retrieved from Make Cities Inclusive, Safe, Resilient, and Sustainable. 2019. Available online: <http://sdg-tracker.org/cities/target> (accessed on 15 April 2020).
15. Vladimirova, K.; Le Blanc, D. *How Well Are the Links between Education and Other Sustainable Development Goals Covered in UN Flagship Reports? A Contribution to the Study of the Science-Policy Interface on Education in the UN System*; DESA Working Paper No. 146; Department of Economic & Social Affairs: New York, NY, USA, 2015.
16. Federal Democratic Republic of Ethiopia (FDRE). *The City of Addis Ababa: Performance Assessment Report*; World Bank Group: Washington, DC, USA, 2020.
17. UNDP Ethiopia. *Ethiopia's Progress towards Eradicating Poverty. Implementation of the Third United Nations Decade for the Eradication of Poverty (2018–2027)*; UNDP Ethiopia: Addis Ababa, Ethiopia, 2018.
18. World Bank Group. *Ethiopia Poverty Assessment. Harnessing Continued Growth for Accelerated Poverty Reduction*; World Bank: Washington, DC, USA, 2020.
19. Wong, C. *Indicators for Urban and Regional Planning: The Interplay of Policy and Methods*; Routledge: New York, NY, USA, 2006. [CrossRef]
20. Pacione, M. *Urban Geography; Global Perspective*, 3rd ed.; Routledge: London, UK; Taylor and Francis: New York, NY, USA, 2009.
21. Bernard, H.R. Research Method in Anthropology. 2011. Available online: https://research-methodology.net/research-methodology/research-approach/inductive-approach-2/#_ftn2 (accessed on 12 December 2019).
22. Kanbur, R.; Venable, A. Introduction: Spatial inequality and development. *J. Econ. Geogr.* **2005**, *5*, 1–2. Available online: <http://hdl.handle.net/10.1093/jnlecg/lbh059> (accessed on 22 March 2022).
23. UN-Habitat. *The State of Addis Ababa 2017 the Addis Ababa We Want*; UN-Habitat: Nairobi, Kenya, 2017.
24. World Bank Group. *Urban Poverty in Ethiopia: A Multifaceted and Spatial Perspective*; World Bank: Washington, DC, USA, 2008; Available online: <http://www.worldbank.org> (accessed on 16 January 2019).
25. Turok, E. People-based versus place-based policy: The 2009 world development report. *Local Econ.* **2013**, *28*, 3–8. [CrossRef]
26. World Bank Group. Towards an Inclusive and Empowered Ethiopia: Improving Social Safety Nets to Reduce Urban Poverty. 14 January 2021. Available online: <https://www.worldbank.org/en/results/2021/01/14/towards-an-inclusive-and-empowered-ethiopia-improving-social-safety-nets-to-reduce-urban-poverty> (accessed on 22 March 2022).
27. Tunstall, R.; Lupton, R. Is targeting deprived areas an effective means to reach poor people? An assessment of one rationale for area-based funding program case paper 17. In *Targeting Deprivations through Qualitative and Quantitative Indicators: A Case Study of Kisumu, Kenya*; Julio, R.P., Ed.; University of Twente: Enschede, The Netherlands, 2003.
28. Crane, R.; Manville, M. *People or Place? Revisiting the Who versus the Where of Urban Development*; Lincoln Institute of Land Policy: Cambridge, MA, USA, 2008.
29. SDG. Goals and Targets from the 2030 Agenda for Sustainable Development. 2018. Available online: [sustainabledevelopment.Un.org](https://sustainabledevelopment.un.org) (accessed on 13 October 2022).
30. World Bank. The World Bank in Social Protection. 7 October 2022. Available online: <https://www.worldbank.org/en/topic/socialprotection/overview> (accessed on 20 October 2022).
31. Elias, A.Y. Revisiting Slums, Revealing Responses: Urban Upgrading in Tenant Dominated Inner-City Settlements, in Addis Ababa, Ethiopia. Ph.D Thesis, Norwegian University of Science and Technology, Trondheim, Norway, 2008.
32. Central Statistical Authority (CSA). *Population Projection of Ethiopia for All Regions at the Woreda Level from 2014–2017*; CSA: Addis Ababa, Ethiopia, 2013.
33. Weldeghebrael, E.H. The Framing of Inner-City Slum Redevelopment by an Aspiring Developmental State: The Case of Addis Ababa, Ethiopia. 2022. Available online: <https://doi.org/10.1016/j.cities.2020.102807> (accessed on 10 December 2022).
34. Berhanu, G.; Woldemikael, S.M.; Beyene, E.G. The interrelationships of sustainable livelihood capital assets deprivations and asset-based social policy interventions: The case of Addis Ababa informal settlement areas, Ethiopia. *Res. Glob.* **2022**, *4*, 100081. [CrossRef]
35. Issa, E.E. Life in slum neighborhood of Addis Ababa, Ethiopia: Morphological facts and their dysfunctions. *Heliyon* **2021**, *7*, e07139. Available online: <https://doi.org/10.1016/j.heliyon.2021.e07139> (accessed on 10 December 2022). [CrossRef]
36. Habitat for Humanity Great Britain. *Slum Housing in Ethiopia: How to Rebuild a Capital City*. 2017. Available online: <https://www.habitatforhumanity.org.uk/blog/2017/11/slum-housing-ethiopia> (accessed on 15 March 2022).
37. Murray, S.C.; Basic Facts on Concentrated Poverty. Center on Budget and Policy Priorities. 2015. Available online: <https://www.cbpp.org/sites/default/files/atoms/files/11-3-15hous2.pdf> (accessed on 7 December 2021).

38. Wilson, J.W. The truly disadvantaged. In *Theories of Urban Poverty and Implication for Public Housing Policy*; Curley, A.M., Ed.; The University of Chicago Press: Chicago, IL, USA, 1987.
39. Shieh, Y.-N. An early use of bid rent functions. In *Wikipedia, Bid Rent Theory*; Urban Studies: Newbury Park, CA, USA, 2003; Volume 40, pp. 791–795. [CrossRef]
40. Narvaez, L.; Penn, A.; Griffiths, S. *Spatial Configuration and Bid Rent Theory: How Urban Space Shapes The Urban Economy*; The Ninth International Space Syntax Symposium; Sejong University: Seoul, Republic of Korea, 2013; pp. 1–19. Available online: <https://www.researchgate.net/publication/315718155> (accessed on 17 September 2022).
41. Tesfaye, E.K. Peri-Urban Land in Ethiopia: Genesis, Dynamic, and Planning. Ph.D. Thesis, Universität Rostock, Rostock, Germany, 2019. Available online: <https://www.uni-rostock.de/storages/uni-rostock> (accessed on 13 October 2022).
42. Van Domelen, J. *Reaching the Poor and Vulnerable: Targeting Strategies for the Social Fund and Other Community-Driven Programs*; Social Protection (SP) Discussion Paper No.0711; World Bank: Washington, DC, USA, 2007.
43. Neumark, D.; Simpson, H. Place-Based Policies. NBER Working Paper 20049. 2014. pp. 1–76. Available online: <https://doi.org/10.3386/w20049> (accessed on 7 September 2020).
44. Smith, G. Area-based initiatives: The rationales and options for area targeting. In *Monitoring Intra-Urban Inequalities with GIS-Based Indicators*; Martinez, A.J., Ed.; Centers for Analysis of Social Exclusion, London School of Economics: London, UK, 1999.
45. Hohmann, R. *Regenerating Deprived Urban Areas: A Cross-National Analysis of Area-Based Initiatives*; Policy Press: Bristol, UK, 2014; Available online: <https://doi.org/10.1332/policypress/9781447310785.001.0001> (accessed on 24 June 2019).
46. Sabine, W.; Ali, M.; Peter, S. Place-based development and Spatial Justice. *Eur. Plan. Stud.* **2021**, *30*, 791–806. [CrossRef]
47. Wahba, S.; Ranarifidy, D.; World Bank Blogs. Retrieved from Re-Awakening Kinshasa’s Splendor through Targeted Urban Interventions. 20 September 2018. Available online: <https://blogs.worldbank.org/african/re-awakening-kinshasas-splendor-through-targeted-urban-interventions> (accessed on 2 October 2022).
48. Tesfay, M.W. The Challenge of Current Upgrading Projects in Addis Ababa, Ethiopia: A Case Study of Chew Berenda Upgrading Project. Ph.D. Thesis, Norwegian University of Science and Technology, Trondheim, Norway, 2016.
49. Bigman, D.; Fofack, H. Geographic Targeting for Poverty Alleviation. World Bank Economic Review 2000. Volume 14. Available online: <https://doi.org/10.1596/0-8213-4625-3> (accessed on 15 January 2019).
50. McLennan, D. *Indices of Deprivations: Mapping the Spatial Distribution of Multiple Deprivations at Small Area Level and Their Uses for Targeting Area-Based Regeneration Policies*; University of Oxford: Oxford, UK; Available online: <https://www.oecd.org/T1/guilsinglighthouse/T1/guilsinglighthouse-policy> (accessed on 13 August 2022).
51. Wikipedia. Multiple Deprivation Index. 2022. Available online: https://en.wikipedia.org/wiki/Multiple_deprivation_index (accessed on 17 September 2022).
52. Coombes, M.; Raybould, S. Developing a Local Enterprise Activity Potential (LEAP) index, Built Environment 14. In *Indicators for Urban and Regional Planning: The Interplay of Policy and Methods*; Cecilia, W., Ed.; Routledge: Oxfordshire, UK, 1989; pp. 107–117.
53. Andrea, R.N. The importance of indices of multiple deprivations for spatial planning and community regenerations: The example of welsh index of multiple deprivations and the related communities’ first program for the Italian system. *Ital. J. Plan. Pract.* **2012**, *2*, 34–65. Available online: <http://www.ijpp.it/index.php/it> (accessed on 22 April 2019).
54. Deas, I.; Robson, B.; Wong, C.; Bradford, M. Measuring neighborhood deprivation: A critique of the index of multiple deprivations. *Environ. Plan. C Gov. Policy* **2003**, *21*, 883–903. [CrossRef]
55. McLennan, D.; Noble, S.; Noble, M.; Plunkett, E.; Wright, G.; Gutacker, N. *The English Indices of Deprivation 2019*; Ministry of Housing, Communities, and Local Government: London, UK, 2019.
56. Glassman, B. *Multidimensional Deprivation in the United States*; American Community Survey Report; United States Census Bureau: Suitland, MD, USA, 2019.
57. UN-Habitat. *Analysis of Multiple Deprivations in Secondary Cities in Sub-saharan Africa*; Cardno: London, UK, 2020; Available online: <http://Sustainabledevelopment.un.org> (accessed on 17 November 2021).
58. Noble, M.; Babita, M.; Barnes, H.; Dibben, C.; Magasela, W.; Noble, S.; Ntshongwana, P.; Phillips, H.; Rama, S.; Roberts, B.; et al. *The Provincial Indices of Multiple Deprivation for South Africa 2001*; University of Oxford: Oxford, UK, 2006.
59. Patel, A.; Shah, P.; Beauregard, B.E. Measuring multiple housing deprivations in urban India using slum severity index. *Habitat Int.* **2020**, *101*, 102190. [CrossRef]
60. Clelland, D.; Hill, C. Deprivation, policy and rurality: The limitations and applications of area-based deprivation indices in Scotland. *Local Econ. J. Local Econ. Policy Unit* **2019**, *34*, 33–50. [CrossRef]
61. Townsend, P. *Poverty in the United Kingdom*; Penguin: London, UK, 1979.
62. Southampton Data Observatory. Deprivation and Poverty in Southampton. 2020. Available online: <http://data.Southampton.government.UK> (accessed on 5 May 2022).
63. Turkstra, J.; Raithelhuber, M. Urban Slum Monitoring. In Proceedings of the 24th Annual ESRI International User Conference, San Diego, CA, USA, 9–13 August 2004. ESRI Conference Paper No.1667.
64. Mitilin, D.; Satterthwaite, D. *Empowering Squatter Citizen an Urban Poverty Reduction*; Earthscan, WWF-UK & International Institute for Environment and Development: London, UK, 2004.
65. Gordon, D. Census based deprivation indices: Their weighting and validation. In *Indicators for Urban and Regional Planning: The Interplay of Policy and Methods*; Cecilia, W., Ed.; Routledge: Oxfordshire, UK, 1995; Volume 49, (Suppl. 2), pp. S39–S44.

66. Martinez, J. *Monitoring Intra-Urban Inequality with GIS-Based Indicators: With a Case Study in Rosario, Argentina*; ITC: Enschede, The Netherlands, 2005; Available online: <https://research.utwente.nl/en/publications/monitoring-intra-urban-inequalities-with-gis-based-indicators-wit> (accessed on 5 May 2022).
67. Whelan, C.T.; Maître, B. Economic vulnerability, multidimensional deprivation and social cohesion in an enlarged European community. *Int. J. Comp. Sociol.* **2005**, *46*, 215–239. [CrossRef]
68. Berthoud, R. Who Suffers Social Disadvantage. In *The Structure of Disadvantage, SSRC/DHSS Studies in Deprivation and Disadvantage?* Brown, M., Ed.; Heinemann Educational Books: London, UK, 1983.
69. Wong, S.; Spatial Organization. Retrieved from International Encyclopedia of the Social and Behavioral Science. 2001. Available online: <https://www.sciencedirect.com/topics/computer-science/spatial-organization> (accessed on 3 May 2019).
70. Yuan, Y.; Fulong, W. The development of the index of multiple deprivations from small area population census in the city of Guangzhou. *Habitat Int.* **2014**, *41*, 142–149. [CrossRef]
71. Qiu, N.; Jianquan, C.; Tianjie, Z. Spatial disparity and Structural inequality in disability patterns across Tianjin municipality: A multiple deprivation perspective. *Habitat Int.* **2022**, *130*, 102685. [CrossRef]
72. Baud, I.; Kuffer, M.; Sliuzas, R.; Sadasivam, K. Understanding Heterogeneity in Metropolitan India: The added value of Remote Sensing data for analyzing sub-standard residential areas. *Int. J. Appl. Earth Obs. Geoinf.* **2010**, *12*, 359–374. [CrossRef]
73. Ajami, A.; Kuffer, M.; Persello, C.; Karin, P. *Identifying a Slums' Degree of Deprivations from VHR Images Using Convolutional Neural Networks*; MDPI: Basel, Switzerland, 2019; pp. 1–24.
74. UN-Habitat. *Slum Almanac 2015/16: Tracking Improvement in the Lives of Slum Dwellers*; UN-Habitat: Nairobi, Kenya, 2015.
75. AACPPPO. Addis Ababa City Structure Plan 2017–2027. *Addis Ababa City Administration: AACPPPO*. 2017. Available online: https://c40-productionimages.s3.amazonaws.com/other_uploads/images/2036_Addis_Ababa_Structural_Plan_2017_to_2027.original.pdf?1544193458 (accessed on 5 May 2019).
76. Kloosterboer, M.H. *The New Addis Ababa: Shanty Town or Global City: An Assessment of Large-Scale Inner-City Renewal, Redevelopment, and Displacement for the Construction of a 'New' Addis Ababa*. Ph.D. Thesis, University of Glasgow, Glasgow, Scotland, 2019.
77. ORAAMP (Office for the Revision of Addis Ababa Master Plan). Centrality. In *Housing Strategies in Inner City Areas: The Case of Low-Income Housing in Inner-City Addis Ababa*; Tesfaye, M., Ed.; Addis Ababa University: Addis Ababa, Ethiopia, 2001.
78. Wikipedia. Addis Merkato. 2022. Available online: https://en.wikipedia.org/wiki/Addis_Merkato#:~: (accessed on 2 November 2022).
79. Abagissa, J. Informal settlements in Addis Ababa: Extent, challenges, and measurements. *J. Public Adm. Financ. Law* **2019**, *15*, 7–30.
80. Central Statistical Authority (CSA). *Addis Ababa Statistical Abstract*; CSA: Addis Ababa, Ethiopia, 2007.
81. Central Statistical Authority (CSA). *Urban Unemployment Survey*; CSA: Addis Ababa, Ethiopia, 2015.
82. Filmer, D.; Pritchett, L. Estimating wealth effects without expenditure data or tears: With an application to educational enrollment in the state of India. In *Targeting Deprivations through Qualitative and Quantitative Indicators*; Julia, P.R., Ed.; SSRN e-library: Enschede, The Netherlands, 1998.
83. Fabrigar, L.R.; Wegener, D.T.; Macallum, R.C.; Strahan, E.J. Evaluating the use of exploratory factorial analysis in psychological research. *Psychol. Methods* **1999**, *4*, 272–299. [CrossRef]
84. Vyas, S.; Kumaranayake, L. *Constructing Socio-Economic Status Indices; How to Use Principal Component Analysis*; Published Oxford University Press in Association with The London School of Hygiene and Tropical Medicine: London, UK, 2006. [CrossRef]
85. Fam, S.-F.; Ismail, N.; Maukar, A.; Yanto, H.; Prastyo, D.; Chuan, Z.L. Weighting method in the construction of area deprivation indices. *J. Fundam. Appl. Sci.* **2018**, *10*, 2655–2668.
86. Vijaya, K. Constructing an area-based socioeconomic index: A principal components analysis approach. In Proceedings of the Early Childhood Intervention Australia (ECIA) 2010 Conference, and Community-University Partnership (CUP), Canberra, Australia, 20–22 May 2010; University of Alberta: Canberra, Australia, 2010; pp. 1–26.
87. Pishghadam, R.; Noghani, M.; Zabihi, R. The construct validation of a questionnaire of social and cultural capital. *Engl. Lang. Teach.* **2011**, *4*, 195–203. [CrossRef]
88. Chojnicki, Z.; Czyz, T. Some problems in the application of factorial analysis in geography. *Geogr. Anal.* **1976**, *3*, 417–427. [CrossRef]
89. Herve, A. Factor rotation in factor analysis. In *The Encyclopedia of Social Science Research Methods*; Lewis-Beck, M., Bryman, A., Futing, T., Eds.; Retrieved from Factor Rotation in Factor Analysis; Sage: Dallas, TX 75083–0688, USA, 2003; Available online: <http://www.utdallas.edu/herve> (accessed on 14 February 2021).
90. Beaumont, R. Retrieved from An Introduction to Principal Component and Factor Analysis: Using SPSS 19 and R (Psych Package). 23 April 2012. Available online: <http://assessment-matters.weebly.com/blogs/an-introduction-toprincipal-component-analysis-factor-analysis-using-spss-19-and-r-psych-package> (accessed on 7 June 2020).
91. Rogerson, P.A. *Statistical Methods for Geography: A Student's Guide*, 2nd ed. ; SAGE: Thousand Oaks, CA, USA, 2006.
92. Lu, Z. *Measuring Urban Poverty: Case Study Wuhan*. Master's Thesis, International Institute for Geoinformation Science and Earth Observation, Enschede, The Netherlands, 2003. Available online: https://webapps.itc.utwente.nl/librarywww/papers_2003/msc/upla/lu_zhoujie.pdf (accessed on 7 March 2019).
93. Mirjam, A.; Alastair, L.; Maria, Y.; Travassos, C.; Ruth, D. Creating small area deprivation indices: A guide for stages and options. *Epidemiol Community Health* **2020**, *74*, 20–25.

94. ESRI (Environmental System Research Institute). How Spatial Autocorrelation (Global Moran's I) Works—ArcGIS Pro Documentation. 7 September 2022. Available online: <https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/h-how-spatial-autocorrelation-moran-s-i-spatial-st.htm> (accessed on 19 October 2022).
95. Anselin, L. Local indicator of spatial association-LISA. *Geogr. Anal.* **1995**, *27*, 84–93. [[CrossRef](#)]
96. Chen, Y. *Reconstructing and Normalization of Anselin's Local Indicator of Spatial Association (LISA)*; Department of Geography, College of Urban and Environmental Science, Peking University: Beijing, China, 2022.

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The interrelationships of sustainable livelihood capital assets deprivations and asset based social policy interventions: The case of Addis Ababa informal settlement areas, Ethiopia

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ABSTRACT

The purpose of the research is to analyze the pattern of interrelationships in deprivations of sustainable livelihood capital assets, sub-groups deprivation variations in light of the theoretical and empirical frameworks, and suggest recommendations for Asset Based Social policy (ABS). The research reviews the approaches of informal settlement interventions vis-a-vis livelihood capital assets, how livelihood capital assets deprivations affect each other, the relationships of assets and functioning of capability, and the institution role on access and control of assets by vulnerable sub-groups. The case study area was from two informal settlements of Addis Ketema sub-city Wereda 07 (the inner-city slum) and kolfe keranyo sub-city Wereda 03 (*peri-urban*). The research applied an explanatory mixed-method sequential design consisting of quantitative research based on a house-to-house random sampling survey, followed by the qualitative method of individual case study and key-informants interview. The research refined strategic issues/ indicators that require ABS interventions from the many aspects of deprivations relationships and argued in line with the theoretical and empirical frameworks. The research implicated strengthening institutions to make livelihood capital assets closer to vulnerable sub-groups, especially in *peri-urban*, empowering community associations bargain for poor rights, reinforce capability functioning for livelihood capital asset accumulation. ABS is crucial for addressing the strategic issue of livelihood capital assets deprivations, tackling institutional and legal constraints, effective functioning of assets and capability, address risk, safety, and vulnerability in informal settlements. The ABS policy improves the wellbeing of poor and vulnerable sub-groups through asset accession, asset valorization, and asset consolidation.

1. Introduction

The framework of the urban planning theories paradigm has influenced the reduction of informal settlement problems and socio-spatial exclusion/deprivation from sustainable intervention perspectives (Lewis, 1966; Abram, 1966; Turner, 1982; De Soto, 2001; Payne, Rakodi, Durand-Lasserve, 2009; Arroyo, 2013; Fontana, 2016). The theory on culture of poverty argued on the vicious circle of poverty and

the means for poverty alleviation is leveraging human capital through raising the class-consciousness of the poor (Lewis, 1966). Abram opposed Lewis (1966) by arguing about empowerment to self-help incrementally focusing on enhancing social capital through the involvement of the community in planning, design, and self-construction (Abrams, 1966; Arroyo, 2013). Turner's modernization theory argued the synergized effect of social and physical capital for self-help incremental building of the poor through government intervention

Abbreviations: ABS, Asset-Based Social Policy; HHS, Households; IHDP, Integrated Housing Development Program; UNDP, United Nations Development Program; SDG, Sustainable Development Goal; UN-Habitat, United Nations Human Settlement Programme; AA, Addis Ababa; FHHS, Female Headed Households; MHHS, Male Headed Households; CBD, Central Business District; CBO, Community Based Organization; SPSS, Statistical Package for Social Science; OWAUV, One Way Anova for Unequal Variance; PPMC, Pearson Product Moment Co-relationship; SRC, Spearman Rank Co-relationship; GIS, Geographic Information System; UPSNP, Urban Productive Safety Net Program; MSSE, Micro and Small Scale Enterprise.

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by providing tenure security, site, and services for curbing informal settlement problems and poverty (Turner, 1982). According to De Soto, accessing physical capital for the poor through property rights and land titling would allow the poor to enter the formal market and escape poverty (De Soto, 2001; Fontana, 2016). Land titling is the crucial livelihood strategy for asset accession of the poor (Dani & Moser, 2008). Direct regularization (not incremental) and property improvement exacerbate poverty for renters and market-based eviction of owners; due to sudden property prices and rental value hikes (Payne, Rakodi, & Durand-Lasserve, 2009). The limited understanding of informal settlement problems leads to deal with the different aspects of deprivations separately (ECE, 2008), therefore; many of the previous urban policies do not explore the range of livelihood capitals.

The inclusive, integrated and resilient approach requires designing strategies and policies for informal settlement reduction and housing interventions considering the access of livelihood capitals assets and rights of the poor (Soma, Sukhwani, & Shaw, 2020; UN-Habitat, 2020a; Wang, Lan, & Wang, 2021b). The current Caribbean informal settlement upgrading followed a comprehensive, integrated and resilient approach including the new urban agenda of leaving no one behind (informal + formal) and the integrated achievement of SDG 11 and SDG 1 (UN-Habitat., 2020b). The current research found a certain linkage between livelihood assets and housing conditions in an urban slum of Dhaka, Bangladesh (Soma et al., 2020). Rural Land Consolidation in China improved initial livelihood capital endowment, reduced vulnerability, and enhanced livelihood capital accumulations (Wang et al., 2021b).

Since most poor in informal settlements do not depend on salaried employment, the livelihood and well-being rather depends on access and accumulate assets, decent return from these assets, and use the asset base to manage risks (Moser & Dani, 2008). Assets mobilization are the key to reduce risk and vulnerabilities (Vatsa, 2004). Yet, informal settlement interventions are not tailored to leverage the poor's access and control over sustainable livelihood capital assets in Ethiopia that lead to policy limitations (Lakisha, 2012; Ministry of Federal Affairs, 2005; Ministry of Urban Development and Housing, 2003; UN-Habitat, 2011; Kloosterboer, 2019). The urban development policy of Ethiopia stipulates the construction of housing estate for low-income groups of society through long-term loans (Ministry of Federal Affairs, 2005). Nevertheless, 70% of the occupiers of the constructed 175,000 condominium units in Addis Ababa (AA), based on IHDP (Integrated Housing Development Program) interventions, rent out the property, and live in informal settlements (Lakisha, 2012).

The above situation implicates the inadequate consideration of the economic opportunities and financial capitals of the poor before implementing massive IHDP. The urban development policy also underscored the promulgation of the legal system on urban renewal through the demolition of houses constructed legally or illegally before the issuance of this policy (Ministry of Federal Affairs, 2005). The policy implementation of urban renewal in AA dismantled social bondage and economic opportunities (UN-Habitat., 2011). Between 2009 and 2016, at least 28,584 HHS (households) of AA were displaced due to inner-city renewal (Kloosterboer, 2019). In 2007, the government drafted a strategy on urban development package focused on job creation, housing, and infrastructure, and a good governance package focused on governance (UN-Habitat, 2014). The above strategy showed the astounding result in job creation and IHDP homeownership but it was not responsive to the livelihood of the chronically poor (Kassahun & Tiwari, 2012). The land management policy enforces timeline systematic regularizations for cities in Ethiopia while preventing the development of future illegal settlements through coercive bulldozing (Ministry of Urban Development and Housing, 2003). Accordingly, the legal enforcement agency still demolished newly formed illegal houses stripping homeownership (physical capital) for the poor in the peri-urban settlements of AA, while squatter settlement proliferation persists currently (T. Getu, personal communication, October 29, 2021). The employment policy of Ethiopia recognized the creation of employment

through sectors (public and private), self, and entrepreneurship (Ministry of Labor and Social Affairs, 2009) though there are significant unemployed population. Nonetheless, currently, the 10-years development plan (2021–2030) recognized the utilization of livelihood capital assets for prosperity and growth (Planning and Development Commission of Ethiopia, 2020).

Currently, sustainable urbanization is one of the major transformative drivers of the 21st century (UNDP, 2012). Yet, the major challenges for sustainable urbanization are the complexities of informal settlement growth and the greater level of spatial, economic, and social exclusion (Jones, 2017). The livelihood capitals possessed by HHS determine comprehensive strategies on livelihood objectives such as income, shelter, security, and general welfare (Ding, Jimoh, Hou, Hou, & Zhang, 2018). A livelihood comprises the capabilities, assets (including both material and social resources), and activities required for a means of living (Serrat, 2017). The livelihood capitals consist of financial, human, physical, social, and natural¹ (Sheilah, Tamsin, Julian., 2001; Farrington, Ramasut, Walker, 2002; UNDP, 2017).

The literature argued the interrelationship between the livelihood capital assets and their pertinence to livelihood strategies of poverty alleviation and sustainable urbanization (Sheilah, Tamsin, & Julian, 2001; Farrington, Ramasut, & Walker, 2002; Baud, Sridharan, & Karin, 2008; UNDP, 2017; SDG Tracker, 2019; Wang, Li, Jin, Yao, & Ji, 2021a). For instance, financial capital in terms of earning and access to employment is strongly dependent on adequate human capital. Physical capital is a key determinant of human and social capital through the link of quality of housing and health as well as mutual support network through social capital (Farrington et al., 2002). Social capital improves the efficacy of economic relationships and equal access to resources and public goods (UNDP, 2017). Poor housing, lack of drinking water and sanitation lead to poor health, preventing people from working effectively and reducing their ability to earn income (Baud et al., 2008). The opportunity cost associated with sub-standard infrastructure impedes education, medical assistance, and income generation (UNDP, 2017). Financial capital is the significant asset to develop and cumulate other assets and support livelihood activities (Wang et al., 2021a). The SDG-11 argued about the link of SDG poverty goal-1 with goal 11 of access to land, slum, and inadequate housing (SDG Tracker, 2019).

The livelihood capital assets interrelationships implicated the crucial role of asset accumulation, which is pragmatic through the functioning of capability. The capability approach focuses on what people are able to be and do with the resources and goods (Robeyns & Morten, 2021). Poverty is viewed as the deprivations of basic capabilities (well-nourished, clothed, married, educated, and healthy) as well as taking part in the life of a community (Sen, 1995). The creation of capabilities strongly depends on the set of capital assets available. The greater the erosion of people's assets, the greater the vulnerability and insecurity (Lienert & Burger, 2015). Individuals and communities are crucial in the expansion of capabilities (Graciela, 2018). Accordingly, the Asset-Based Social policy (ABS) shifted from income/consumption to the critical role played by asset and capability in improving wellbeing (Moser, 2008). The first generation of ABS provides individuals and HHS to further accumulate livelihood capital on their own and move out of poverty. The second generation focuses on asset consolidation and preventing erosion (Caroline & Moser, 2006). The ABS accumulate assets through stages of asset accession, valorization, and transformation (Dani & Moser, 2008; Moser, 2008). Asset accession focuses on increasing the capability of the

¹ Financial capital includes income from the sale of labor, saving, and credit. Human capital is the skill, knowledge, access to training/education, ability to labor, and good health. Physical capital includes housing people use, own, and rent as well as, infrastructure and services access. Social capital is a set of shared values that allows individuals to work together in a group to effectively achieve a common purpose. Natural capital is significant in cities in cases of river pollution and people eviction due to urban agriculture.

poor to strengthen the asset base. Asset valorization focuses on public investment to increase the return or value of assets and asset transformation focuses on transformational public policy and secure livelihood overcoming constraints (Dani & Moser, 2008). The contemporarily social policy is transformational adheres to the principle of universalization, integration of policy, inclusiveness, and alignment with global/social regional policy (United Nations, 2021). UPSNP (Urban Productive Safety Net Program) was implemented in 2016 in Ethiopia to enhance asset accumulation through offering protection of the urban community, providing income and employment opportunities in public works (Gebreselassie, 2019; Abiy, 2020). Despite no country wide evaluation on UPSNP, the evaluative research on Mekele city revealed UPSNP improved beneficiaries' income, protected livelihood risks, and enhanced food security (Gebresilassie, 2019).

MSSE (Micro and Small Scale Enterprises) is an institutional asset for poverty alleviation and employment generation through the functioning of capability. Yet, the problems of revolving fund recovery for traditional collateral based lending stunted MSSE's. Accordingly, asset-based lending and special funding for MSSE (Micro and Small Scale Enterprises) shall be the alternative options to ensure the success of MSSE (Nega & Edris, 2016) and expansion of capital asset accumulation.

The sub-groups (gender, age, household types, employment status) varied by access to resources, right, goods, and services in line with social-exclusion theory (Levitas, 2006). Jayamohan and Amenu (2014) research argued the feminization of poverty is a weak argument in urban Ethiopia based on the sole assessment of income. Half of the unemployed of AA in 2014 were youths completing secondary and post-secondary education (Federal Democratic Republic of Ethiopia, 2018). Aboderin, Kano, and Owil (2017) underscored the vulnerability of the old slum dwellers sub-groups, which needs old age slum mainstreaming initiatives. People's capability also varied in what they are able to do and be with those resources (Robeyns & Morten, 2021) with implications for sub-group variations. Institutions affect the range of livelihood capitals by controlling and influencing how, when, and by whom they are used (Messer & Townsley, 2003). In other words, an institution can leverage the control and access of livelihood capitals by sub-groups. The institution includes the organization of formal, informal, political, economic, and socio-cultural (Carloni & Crowley, 2005). Institution structure, policy, legislation, and process transformed livelihood strategies similar to access to livelihood capitals (Carloni & Crowley, 2005; Serrat, 2017). Accordingly, pro-poor public policies need to focus on creating institutional conditions to allow poor and vulnerable people to build and obtain a return on assets (Dani & Moser, 2008). Local institutions strengthened Social capital (UNDP 2017) and social capital facilitate access to livelihood capitals for vulnerable sub-groups. The insight from South Asian research indicated inaccessibility of enabling institutional support for building assets exacerbated poverty (Shahbaz, Vinod, Geiser, Sadaf, Schäfer, Müller-Böcker, 2010). Limited organizational capacity might reduce the social network to access credit and labor (Bebbington, n.d) that especially affect vulnerable sub-groups.

The research selected two case study areas from inner-city slum and *peri-urban* of AA based on two slum model dichotomies of an informal settlement in line with authors (Eckstein, 1990; Stoke, 1962). Stoke (1962) argued inner-city slum (slum of despair) and *peri-urban* or squatter settlement (slum of hope), while Eckstein (1990) reasoned out the reverse of the slum model of Stoke (1962). Despite the slum theoretical model being debatable in a different context, the consensus is the dichotomous nature of slum settlement for selecting the two case study areas. Accordingly, the Addis Ababa (AA) case study area was Addis-Ketema sub-city Wereda-07 inner-city slum ('inner-city slum') and Kolfe-Keranyo sub-city Wereda-03 *peri-urban* squatter settlement ('*peri-urban*').

In line with Walker and Baxter (2019), the research followed an explanatory sequential design that quantitative analysis provides general comprehension while qualitative data of individual case studies and interviews refine and explain the statistical result. Accordingly, the

three research questions are the following. 1) Is there a pattern of the interrelationships among deprivations of sustainable livelihood capital assets, based on the findings and/or in light of theoretical and empirical frameworks? 2) Are there variations in deprivation of sustainable livelihood capital assets by sub-groups based on findings and/or in light of theoretical and empirical frameworks?

3) What are the recommended asset-based social policy interventions? The sub-groups for this research were disaggregated HHS by income status, gender, tenure status, unemployment, and education status.

2. Background information

The world population living in cities was 54% in 2015 and projected to be 70% in 2050 (UNDP, 2012; World Bank, 2015a). Empirical analysis showed that a 1 % increase in population growth increases the incidence of a slum in Africa by 2.3 % (UN-Habitat, 2020a) indicating urbanization of poverty. Yet, according to authors (Mitilun & Satterthwaite, 2004; UN-Habitat 2003; World Bank, 2015b), urban poverty is underestimated relative to rural poverty due to failure to make adjustments for rising costs of living and poor definition of access to infrastructure or services.

Ethiopia has a low level of urbanization, which is 21.2% in 2019 (Mezgebo, 2021). Nonetheless, the country's urban growth is at a high rate of 3.8% per annum, which would lead to the tripling of its urban population by 2037 should this growth rate remain constant in the meantime (World Bank, 2015a). Ethiopia's urban population had more than doubled from 4.87 to 11.6 million between 1984 and 2007. The AA unemployment rate was 28.6% for 15–64 age groups (CSA [Central Statistics Agency of Ethiopia], 2015). AA has 10 sub-cities and the selected case study areas were from Addis-Ketema and Kolfe-Keranyo sub-cities. The old inner-city slum in Addis Ababa covers 11% of the total area of 54,000 ha, which includes the sub-cities of Lideta, Kirkos, Addis Ketema, Arada, and some parts of Kolfe-Keranyo, Gulele, and Yeka sub-cities (Elias, 2008). The inner-city slum in Addis Ababa is the legacy of houses constructed informally before the 1974 revolution (Solomon & Mcleod, 2004).

Addis-Ketema sub-city has 10 weredas. According to Zafu and Peter (2014), Addis-Ketema sub-city inner-city slum is aged, centrally located, dilapidated, overcrowded, formalized tenure dominated by tenant houses, low-income people, subject to flooding, and endowed with poor services. Kolfe Keranyo had 15 Weredas. kolfe Keranyo *peri-urban* is the dwelling site for migrants arriving from different parts of the country (M.G/Egziabhere, personal communication, June 12, 2018). The Kolfe Keranyo *peri-urban* settlement lies at the edge of Addis Ababa. Some of the tenures of *peri-urban* were regularized using 1994 E.C (Ethiopian Calendar) aerial photograph and 1997 E.C satellite image. The *peri-urban* squatter settlements evolved in the 1990 s (Kassahun, 2010) and increased since 1994 (Minwuyelet, 2005). The *peri-urban* proliferation of informal settlements has become rampant after the regularization (World Bank, 2016). The first study area was from Addis-Ketema Wereda 07(inner-city slum), and the second study area was from Kolfe-Keranyo wereda 03 *peri-urban* settlement (*peri-urban*).

The inner-city slum: it is in the Addis-Ketema sub-city consisted of four Kebele administrations (kebeles 29, 30, 32, and 34). The estimated population size was 32,646 and the growth rate was 3% in 2018 (CSA, 2013a, 2013b). The total surveyed population and HHS of the inner-city slum were 2435 and 404 in 2018, respectively. The mean HHS was 4.8 people (CSA, 2007). The area and population densities were 49.88 ha and 654 people/hectare in 2018. 59.4% of the total HHS were FHHS (Female-Headed Households). The mean household size was "6". The overcrowdedness was 4.01. About 25.3% of HHS had a mezzanine floor ('kot' in Amharic) for renting/living. About 61.3% of HHS had lived in their dwelling unit for >30 years. The largest ethnic group was the Amhara (38.4% HHS). The majority (74.3%) of the dwellers followed the Ethiopian Orthodox Christian. The Married and Widowed HHS

constituted 44.3% and 27.5 %, respectively. About 20.5% of HHS were learning Read and Write. 65.5% were migrants. About 97.52% of HHS had de jure tenure right (Permit Right, Kebele house renter, Municipal house renter). Based on additional questions on previously surveyed HHS for Kebele 32 and 34 of Wereda 07, 39.3% of HHS rented beds for temporary and recent migrants. The above findings depicted Alonso's model regarding how the poor outbid the rich and survive in a CBD (Central Business District) through overcrowding, renting, and exploiting the reduced transport cost opportunity (UN-Habitat, 2003). About 90.3% were involved in CBO (Community Based Organization) such as 'Edir' and 'Ekub'. Election participation for 20 % of HHS was low and very low. About 43.6% of HHS earned incomes below the absolute poverty line of Ethiopia (< 599 birrs per month per Adult Equivalent in 2016). The average mobility from work to home was 13 min for inner-city slums due to near old CBD. The unemployment rate for the 18–64 and 18–29 age groups was 33.71 % and 24.33 %, respectively.

Peri-urban: Kolfe-Keranyo Wereda-03 *peri-urban* is a settlement mainly formed through informal land transactions. The *peri-urban* population was scanty and spontaneous during the 2007 Ethiopian census period; therefore, there was no officially recorded figure per geographic jurisdiction. Yet, based on information from the Wereda-03 building permit office and residents, there were 2500 HHS in 2018. Considering 4.35 HHS for the kolfe keranyo sub-city (CSA, 2007), the estimated population was 10,875. The area and population densities for 2018 were 45.96 ha and 237 persons/hectare, respectively. The total surveyed population was 1212 (HHS = 252) for 2018. The MHHS (Male Headed Households) constituted 78.57%. The mean household size was "4.8". The overcrowdedness was 2.67 people per room. 100% of *peri-urban* HHS had no mezzanine floor. 75% of the *peri-urban* HHS had lived in their dwelling units for less than ten years. From the total HHS, the Gurage ethnic groups and Muslim religion followers were 50.4 % and 58.7 %, respectively. The Widowed HHS constituted 3.6%. HHS attended 5–8 grade was 48.4 %. Migrants constituted 90.5% of the HHS. 81.7% of HHS had no recognized tenure (unauthorized dwellers/renters). About 76.6% were involved in CBO. Election participation for 24.6 % of HHS was low and very low. About 22.6% of HHS earned incomes below the absolute poverty line of Ethiopia. The average mobility from work to home was 42 min. The unemployment rate for the 18–64 and 18–29 age groups was 20.4 % and 15.63%, respectively.

3. Methodology

Based on the recognized two slum dichotomies, the researchers selected case study areas from an inner-city slum and *peri-urban*/squatter settlement. Slum of hope is a new, self-built structure, usually illegal (squatters) that are in or have recently been through a process of development, consolidation, and improvement. Slum of despair is 'declining' neighborhoods, in which environmental conditions and domestic services are undergoing a process of degeneration (inner-city slum) (Stoke, 1962; UN-Habitat, 2003). Eckstein (1990) reasoned out the reverse of the slum model: Squatter settlement as the slum of despair and inner-city slum as the slum of hope.

The research followed an explanatory sequential design based on Walker and Baxter (2019), collecting quantitative data through HHS face-to-face interviews, physical validation and GIS analysis. Then, the quantitative data is further enriched and validated with qualitative data collected through an individual case study and key informant interviews. The theoretical and conceptual lens of multiple aspects of livelihood capital assets deprivations, in addition to regulatory framework reviews, provides bases for defining variables or questions for quantitative research. The individuals' case study enabled finding in-depth and real-life situations of vulnerable participants following Rebolj (2013). The targeted participants for the individual case study were nine purposively selected persons (chronically poor women, poor women renter, two tenure right dispossessed men, women vulnerable to poor sanitation, CBO member widowed women, CBO member men, and

two women vulnerable to poor infrastructure). The researcher made an in-depth key-informant interview with sub-city and Wereda local administrations on livelihood aspects of an institution, capability, risks, safety, and other issues. Key informant interviews were executed for twelve(12) government staff from *peri-urban* and the inner-city slum, respectively.

The key-informant interview and individual case study enriched the external validity of the research using open-ended questionnaires. The quantitative questionnaires consisted of sections of area and location identification (6 questions), HHS basic characteristics for HHS (26 questions) & housing (14 questions), service and infrastructure (9–10 questions), regulatory and perception related (18). The question for service and infrastructure is 9 for the inner-city slum and 10 for *peri-urban*. For quantitative research, systematic random sampling was conducted on the two areas based on Yamane (1967) formula for the finite population as follows:

$$n = \frac{N}{1 + N(e)^2}$$

Where, N = Number of Household in the population, e = level of significance varies based on research conditions.

For quantitative research, the data collectors were four (4) for the inner-city slum and two (2) for the *peri-urban*. The data collectors (minimum bachelor degree) took orientation on questionnaires, and the questionnaires were tested and updated on the pilot area before full scale-up. The data collectors filled the questionnaires by face-to-face interview with each household (HH) and performing physical validation. The SPSS analysis filtered the vulnerable sub-groups from the collected quantitative data. The researcher validated data collectors during the field survey through sample field checks and revisiting some areas for bridging the gaps on unfilled questionnaires. The research analyzed the variables using statistical tools of Chi-square test (χ^2), One Way Anova for Unequal Variance (OWAUV), Pearson Product Moment Coorelationship (PPMC), Spearman Rank Coorelationship (SRC). The GIS software analyzed spatial data(service, infrastructure, and topography) and integrated it with the database of the questionnaires in SPSS. The specific approaches for Inner-city slum and *peri-urban* are described below.

Inner-city slum: Addis ketema sub-city was selected purposively from AA, due to its location near the old CBD, the main transport hub, and large market. Then, the researchers selected the Wereda-07 inner-city slum from the ten weredas purposively by consulting with Addis-Ketema sub-city officials, supported with preliminary field verification. Accordingly, wereda 07 inner-city slum houses were aged, dilapidated, overcrowded, degenerated services, near the old CBD, and intact settlements (not affected by renewal). The projected population and HHS size for Addis Ketema Wereda 07 in 2018 were 32,646 and 6801, respectively. The projection considered the base population of the wereda according to CSA, 2007 and the 3 % annual growth rate of AA in 2017 (CSA, 2013a). The envisaged sample survey was 378 HHS, from the overall HHS size of 6810 HHS for wereda 07, at 0.05 level of significance. Yet, the actual data entry was 404 HHS tagged with GPS coordinates, suffices survey considering the relative heterogeneity and dense nature of the area. Accordingly, each member of the 6th HHS was questioned and surveyed. Hence, the external validity of the research was ensured by triangulating the collected survey information with a base map and rental house information of the Addis Ketema Wereda 07 office as well as an individual case study and key-informant interview

Peri-urban: to filter consolidated squatter settlements, the regularized building structure of AA (based on a satellite image of 2005) overlaid on a recent google image of 2018. Accordingly, Kolfe-Keranyo and Bole sub-city were the main squatter settlement expansion areas. Yet, the trends of expansions were relatively increasing for Kolfe-Keranyo, based on the filtered spontaneous settlements and the further verification of the previous research of Minwuyelet (2005). According to Kolfe keranyo Sub-city Transitional Land Administration Project office, Wereda 03 portion of areas was one of the weredas' with consolidated squatter settlement (G.Gebreegziabhere, personal communication, June 12,

2018). Then, based on the building permit office of wereda 03 information, the squatter area of wereda 03 was delineated; and the total HHS in the delineated area was 2500. Accordingly, the targeted HHS for the sample survey was 250 at a 0.06 level of significance. Yet, the performed data entry was 252 HHS, which was a sufficient sample considering the relative homogeneity of the area. Accordingly, every 10th HHS was questioned and surveyed by data collectors.

The soft wares used for Analysis are IBM SPSS Statistics 20 and ArcGIS 10.4.1. The test used in the research was the Chi-square test, OWAUV, PPMC and SRC. In chi-square test, not significant associations were not included ($p > 0.05$). The income per Adult Equivalent (AE) considers the different calorie requirements of adults and children. According to authors (Shinns & Lyne, 2002), $AE = (No.Adult + 0.5 \times No.Children)^{0.9}$. The absolute poverty line of Ethiopia for 2015/16 is less than birr 7184 per year per AE (<599 Birr/Month (M)/AE) (National Planning Commission of Ethiopia, 2017).

Result

Financial capital interrelationship with other livelihood capitals

The OWAUV revealed a significant difference in the percentage of expenditure for food, water, energy, and transport. Inner-city slum and *peri-urban* HHS on average spent 61.36 % and 55.8 % on food, respectively. On the other hand, the inner-city slums and *peri-urban* spent < 5 % and 9 % on transport, energy/light, and water, respectively. The food expenditure % versus income per AE PPMC was -0.33 and -0.284 for the inner-city slums and *peri-urban*, respectively. The above result indicated the poorer the HHS, the more reliance on cash-economy for food security. The income per AE versus energy/light % expenditure PPMC was -0.33 and -0.32 for inner-city slums and *peri-urban*, respectively. Similarly, the lower the income per AE, the higher % of investment in energy and light. A woman in a *peri-urban* area expressed the poverty and survival mechanism for the high-energy cost of charcoal as follows:

I am the only person supporting my children and husband by selling candles in front of the Kidane Mihretchurch. My husband suffers from a mental illness. I have been compelled to sell my household's furniture to treat him. In order to cover the high cost of charcoal, I use charcoal residuals provided freely by charcoal sellers mixed with the soil which sustains long for cooking (Case study -1, 2018, Kolfe Keranyo Wereda 03 *peri-urban*).

There was significant association between Sanitation Vulnerability² and HHS income per AE for inner-city slum ($\chi^2 = 36.635$, $df = 12$, $\alpha = 0.001$) and for *peri-urban* ($\chi^2 = 51.411$, $df = 12$, $\alpha = 0.001$). The fact was explained by the % of non-vulnerable to sanitation was 5.68% and 41.48% for HHS with income < 599 birr/M/AE and ≥ 3000 birr /M/AE, respectively. For *peri-urban*, the percentage of non-vulnerable to sanitation was 1.75 % and 16.67% for HHS with income < 599 birr/M/AE and ≥ 3000 birr /M/AE, respectively (Table 1).

The OWAUV indicated significant differences in rental value per tenure status for the inner-city slum ($\alpha < 0.001$). The average rental value was birr 16.3, 175.72, 591.8, 1420.41, 2942.86 for Kebele House

Rent, Municipal House Rent, Rented from Unauthorized Dwellers, Sub-Rent from Kebele house Rent and Rented from Owner Permit Right, respectively. The renters from owners of a Permit right and sub-rented from a renter of Kebele House(government rented house) renter were paying an exorbitantly high rent price. A female HHS, who rented a dwelling unit from the owner with permit right, expressed the exorbitant rent affecting her livelihood as follows

My livelihood depends on selling "Areke"(traditional alcoholic drink) renting a 12 m2 house paying 1,000 Ethiopian birr per month. I paid the rent until now by saving through the local saving organization(Ekub). Yet, currently, the previous owner sold the house to another person, and the new proprietor asked me to pay 10,000 Birr per month; if not, he will rent it to a tenant who intends to use the structure as a bookstore. The Wereda office responded that they did not involve in matters of the legally transacted house. Now I am really in deep grief since my livelihood depends on selling "Areke" otherwise I will be on the street (Case study -2, 2018, Addis Ketema Wereda 07 inner-city slum).

There was a significant association between income per AE with Water source for *Peri-urban* ($\chi^2 = 29.417$, $\alpha = 0.001$). The association for *peri-urban* was explained by 33.3% and 16.66 % of HHS with income < 599 birr/M/AE and ≥ 3000 birr/M/AE were respectively fetching water from spring with long waiting(4 jerricans per 15 days paying 10 birr per month in 2018). Similarly, HHS who use mainly vendor-provided water³(10-13 birr/25 L Jerrican) were 26.14% and 61.4% for HHS with income per AE < 599 birr/M/AE and > 1500 birr to ≤ 3000 birr/M/AE, respectively. The SRC between income per AE and water consumption per Jerrican in liter for *peri-urban* was 0.4. The result indicated that the poorer the HHS in *peri-urban*, the less water consumption and the less afforded vendor-provided water. Based on interviewing women and observation, the poor women in *peri-urban* brought potable water from the formal neighborhood with reduced cost of 2 birr per 25 L jerrican to mitigate the high cost of vendor-provided water.

There was a significant association between income per AE and building floor material for the inner-city slum ($\chi^2 = 71.783$, $\alpha < 0.001$), and there was also an association between income per AE and housing wall material for *peri-urban* ($\chi^2 = 9.905$, $\alpha = 0.042$). The association for the inner-city slum was due to 54.35% and 1.09% of mud-floor houses had HHS income < 599 birr/M/AE and ≥ 3000 birr per M/AE, respectively. The association for *peri-urban* was due to 100% of HHS with < 599 birr/M/AE constructed wall material with wood/mud. The PPMC between income/person/month and parcel area/person for *peri-urban* was 0.447. So, the higher income corresponded with large parcel per capita for land speculation of *peri-urban*. The PPMC between income/person/month and building area per capita was 0.365. The above result indicated the vulnerability of the poorest of the poor for unhealthy and congested living conditions. The SRC between Income per AE and Mobility in minutes from work to home was 0.31 and 0.168 for the *peri-urban* and inner-city slum, respectively. The result implicated the higher likelihood of going long distances for employment opportunities for better income HHS of *peri-urban*.

4.2. Interrelationships within human capitals and human capitals with other livelihood capitals

The PPMC between the number of unemployed youth/18-29 age group/ with HHS members with educational status grade 9-10 was 0.334 and 0.302 for the inner-city slum and *peri-urban*, respectively. The result indicated HHS members who completed grade 10 but did not

² Sanitation Vulnerability category: zero (No vulnerability: -pour Flush latrine shared by ≤ 5 HHS and Clean or Ventilated pit latrine shared by ≤ 5 HHS). One (Slightly Vulnerable:-Unventilated Pit latrine (not Shared) and Flush Latrine/latrine connected to Septic tank shared by > 5 and ≤ 10 HHS). Two (Vulnerable: Unventilated Pit latrine Shared by 2-10 HHS and Flush Latrine/connected to septic tank shared by > 10 and ≤ 20 HHS), Three (High Vulnerable: Unventilated Pit latrine Shared by > 10 and ≤ 20 HHS and Flush Latrine/connected to septic tank shared by > 20 HHS), Four (Very High Vulnerable: Excreta Open Field, Bucket or Service latrine or Pit Latrine Shared by > 20 HHS).

³ The fetching of water(mostly by women) going a long distance of 1.5-2km with a cost of 1.5-2.5 birr for 25 liter Jerri can in 2018.4Formal employment considers those who depend on employment of Government , Formal Private organization, and Formal Self-employed business.

Table 1
 recommendation for Asset accession, Asset valorization and Asset transformation for attaining ABS policy, disaggregated by livelihood capital assets.

LivelihoodCapitalassets	Asset accession	Asset valorization	Asset transformation
Humancapital	<ul style="list-style-type: none"> - Registering and targeting low education level HHS(with gender mainstreaming) for informal education provision. - Ensure food security/nutrition's and participate in livelihood capital asset accumulation public works for the poor and vulnerable HHS Sub-groups. - Priority of MSSE employment opportunities for unemployed youths who failed secondary educations. - Public awareness on transmittable diseases, especially for vulnerable HHS (overcrowding, poor environment services). - Provide social protection for vulnerable HHS sub-groups (old and disabled) who cannot engage in productive work. 	<ul style="list-style-type: none"> - Investment in informal education for low education level HHS with gender mainstreaming. - Investment in skilled training tailored to the functioning of capabilities of the poor and vulnerable HHS sub-groups. - Investment in technical vocational training through providing priorities for youths who failed secondary education - Investment and awareness training on transmittable diseases by providing priority for high vulnerable sub-groups 	<ul style="list-style-type: none"> - Recognizing informal education in formal government and private work opportunities. - Certification accrediting the capability of poor and vulnerable HHS sub-groups. - Policy design and implementation to provide job opportunities for the poor and vulnerable HHS sub-groups in the work they are capable and do (the functioning of capability). - Policy design and implementation to provide priority of job opportunities based on capabilities for youths who failed secondary education. - Commence regular mass media program for transmittable disease prevention and health resilience.
Physical capital	<ul style="list-style-type: none"> - Recognize the various forms of rights for all tenure groups including group tenure and occupancy rights for landless in regulatory frameworks. - Authenticate and recognize the right to residence and on-site accommodation planning regulations (upgrading, land consolidation/ readjustment, land-sharing, and low-income housing) - planning policy and housing design to ease overcrowding 	<ul style="list-style-type: none"> - Investment in the provision of various forms of tenure such as group tenure and occupancy right for landless - Subsidize and invest in services and infrastructure provision for informal settlements, especially in socially excluded and inaccessible areas. - Investment in the implementation of planning and housing design to ease overcrowding. 	<ul style="list-style-type: none"> - Legitimize and transform the occupancy and group tenure right to lease right incrementally. - The informal settlement neighborhoods integrated with mainstream formal urban development. - Remove legal frameworks (building permit and regularization) that exclude physical capital asset accumulation for poor and vulnerable HHS sub-groups. - Housing policy implementation ensures on-site accommodation and vertical development (less overcrowding).—Ownership right recognition inhibits relocation and eviction of the poor and the land right dispossessed HHS .
Financial capital	<ul style="list-style-type: none"> - Subsidizing the living cost of the poor (food, water, sanitation, health, transport, and education) and vulnerable sub-groups incorporated in multilateral and bilateral agencies programs through cash transfer and subsidies. - Local administrative offices avail foodstuff at a subsidized cost for the poor HHS and vulnerable sub-groups. - School feeding for poor students. - Introducing energy-saving and cost-effective cooking technologies. - Recognize the role of social inclusion (formal + informal) in matching fund contributions. - Facilitate financial institutions that provide a low-interest rate for poor and vulnerable sub-groups MSSE involvement. - Design methods and incorporate benchmarks for diversifying income sources for the poor. 	<ul style="list-style-type: none"> - Investment in training regarding saving, entrepreneurship, and diversifying income sources for beneficiaries HHS in partnership with government, multilateral and bilateral agencies. - Private organizations provide asset-based lending for machinery and equipment. - Opening blocked saving bank account for beneficiaries HHS that guarantee credit opportunities. - Investment in producing energy-saving and cost-effective cooking materials and distributing for the poor and vulnerable sub-groups at low cost. - All dwellers contributed matching funds (formal + Informal) - Provide low-interest-rate priority for chronically poor and vulnerable sub-groups for MSSE development. 	<ul style="list-style-type: none"> - The saving groups obtained credit opportunities to engage in job opportunities they are capable and do. - Opportunities for asset-based lending for the poor and vulnerable sub-groups based on legitimized right as collateral for credit. - Scale-up energy-saving and cost-effective cooking technologies to other informal settlements. - Legal framework recognized the contribution of matching funds by all dwellers. - Chronically poor dwellers established profitable MSSE. - Diversifying income sources enhance capital consolidation.
Social and institutional capital	<ul style="list-style-type: none"> - Formulate, increase and recognize the legitimacy of CBO and civic societies in local organization structure as partners of livelihood capital asset accumulation. - Government recognizes and supports programs and projects of multilateral and bilateral agencies working in poverty alleviations and asset building. - Government and the dwellers recognize and strengthen the existing structure of community police. 	<ul style="list-style-type: none"> - Investment in training and memberships of CBO and Civic societies that worked for the interest of the poor and vulnerable sub-groups. - Decentralize the institution of community police at the community level and invest in human capital deployment and trainings. 	<ul style="list-style-type: none"> - Redesign Urban development policy and strategies to accredit and legitimize institutions bargaining for the needs of chronically poor, voiceless, and dispossessed land rights HHS. - Strong multistakeholders partnership of CBO, Civic societies, multilateral and bilateral agencies. - Design social protection policy integrated with employment, poverty and environment policy. - CBO and civic societies bargain for rights in tenure, provision of services and infrastructure, inhibiting evictions for the voiceless poor and dispossessed land right HHS. - Making pragmatic safety and security regulations to reduce crime.
Natural Capital	<ul style="list-style-type: none"> - Recognize the role of UPSNP, multilateral/ bilateral agencies, and civic societies for the protection of natural capital erosion. 	<ul style="list-style-type: none"> - Investment in providing awareness training regarding environment protection and management. - Integrate the poverty alleviation programs investment with natural capital asset accumulations. 	<ul style="list-style-type: none"> - Building an environmentally resilient city that can respond effectively in case of shock and stress. - Reduce the effect of environmental disaster on other livelihood capital assets.

progress in further education, constituted the highest youth unemployed. There was a significant association between gender and occupational status for inner-city slum ($\chi^2 = 52.316$, $\alpha = 0.001$) and peri-urban ($\chi^2 = 29.581$, $\alpha = 0.001$). The above association was due to 23.7% of FHHS in the inner-city slum (against 12.2% for MHHS) relying on assistance from children/relatives. Similarly, 3.3 % of FHHS (8.53% of MHHS) depended on government employment as the livelihood source. Similarly, for peri-urban, the above association was due to 16.67% of FHHS (28.79% of MHHS) were depending on formal employment⁴. There was significant association between gender and HHS educational status for inner-city slum ($\chi^2 = 44.919$, $\alpha = 0.001$) and for peri-urban ($\chi^2 = 11.079$, $\alpha = 0.05$). The above result for the inner-city slums was attributed to 16.25% of FHHS (9.15% MHHS) being illiterate. In other words, 1.77 illiterate women for every male for the inner-city slum. For peri-urban, 38.5% of FHHS (15.24 % MHHS) belonged to either basic read and write or 1–4 education level. In other words, 2.15 less educated women for every male for peri-urban. The significant association between marital status with an occupational category for the inner-city slum ($\chi^2 = 82.862$, $df = 45$, $\alpha = 0.001$) has gender implications. In the inner-city slum, 50.64% of the widowed HHS depended on assistance from children/relatives (85.9% of the widowed were FHHS). The above result explained that the widowed FHHS were the most vulnerable to unemployment. From HHS > 60 years of age, 62.3 % and 0.79 % were surviving through the assistance of children and relatives for the inner-city slum and peri-urban, respectively.

There was a significant association between the education level of the HHS and % of family members progressing \geq diploma education level for the inner-city slum ($\chi^2 = 29.008$, $\alpha = 0.016$) and peri-urban ($\chi^2 = 31.018$, $\alpha = 0.001$). The above result for the inner-city slums was explained by 59.3% and 30.8% of HHS of illiterate and \geq diploma level did not have any HHS members progressing to \geq diploma level, respectively. The association for peri-urban was explained by 100 % and 60% of HHS with educational level illiterate and \geq diploma education level did not have any family members progressing to \geq diploma education level, respectively.

There was a significant association between Unemployment and Overcrowdedness status for the inner-city slum ($\chi^2 = 48.424$, $\alpha = 0.001$). The percent of employed HHS family members (18–64 age group) for the inner-city slum was 69.2 % for the overcrowded category < 1 people/room while 34.9% for the overcrowded category > 5 people/room. There was also a significant association between overcrowdedness and HHS grade level for the inner-city slum ($\chi^2 = 48.424$, $\alpha = 0.002$). The above association was due to HHS with high overcrowdedness (>3 people/room) was 63% and 19.23 % for illiterate and \geq diploma education level, respectively. Accordingly, the less educated HHS in the inner-city slum were likely to be living in highly overcrowded housing. Yet, some dwellers in the inner-city slum had tenure insecurity though they lived three decades as described below.

I have lived in the area for 29 years (since 1989) near the end of the Derg regime⁵. The site was waste disposal during the Derg regime. We have participated in the Kebele election and fund contributions for development activities. I am now a grandfather, and my children were born and brought up here. We have consistently written letters to Addis Ketema sub-city Wereda 07 office to be legalized at least with Kebele House rent. However, local authorities did not answer our consistent plead. We felt high insecurity by fearing that the government may evict us from the place without alternatives for our future livelihoods (Case study-3, 2018, Addis Ketema Wereda 07 inner-city slum).

4.3. Interrelationships within physical capital

There was a significant association between overcrowdedness and sanitation vulnerability for the inner-slum ($\chi^2 = 54.587$, $\alpha < 0.001$). The association for the inner-city slum was due to the non-vulnerable to sanitation constituted 61.5% and 5.8 % for HHS < 1 person/room and for HHS ≥ 4 to < 5 person per room, respectively. The above findings indicated overcrowdedness liable the poor dwellers to sanitation and transmissible diseases. There was a significant association between tenure status and HHS water source for inner-city slum ($\chi^2 = 65.269$, $\alpha < 0.001$). The association was due to Vendor provided water being the major source for 60 %, 8.77%, and 0% of the unauthorized dwellers/renters, owner permit right holder, and Municipal house renters, respectively. The Unauthorized tenure status in the inner-city slum was the most deprived of own piped water connection. There was a significant association between Sanitation vulnerability and Tenure status of HHS for inner-slum ($\chi^2 = 33.348$, $\alpha = 0.031$) and peri-urban settlement ($\chi^2 = 22.869$, $\alpha = 0.029$). The above result was due to 100% of unauthorized dwellers and 48.51% of the renter from unauthorized dwellers categorized into high and very high vulnerable to sanitation for the inner-city slum and peri-urban respectively. The association of tenure right deprivation with poor sanitation/water services quarter of inner-city slum indicated the impact of the absence of de jure tenure right on the bargaining power of the poor for more services.

An authorized dweller who lived in the inner-city slum elaborated that:

The toilet that serves 46 HHS' is overflowing, not repaired despite appealing for Wereda 07 office. Therefore, the 46 HHS in the neighborhood is using a public toilet in CCF office area (consisting of 34 toilets) through paying 12 birr per month while during at night and illness we are suffering due to lack of toilets (Case study –4, 2018, Addis Ketema Wereda 07 inner-city slum).

There was a significant association between tenure status and Water vulnerability⁶ for inner-slum ($\chi^2 = 70.289$, $df = 15$, $\alpha < 0.001$). The association for the inner-slum was due to 70%, 11.3%, and 0% of the unauthorized dwellers, the owner permit right, and municipal house renters were highly vulnerable to potable water shortage. The result indicated that dwellers with no de jure tenure rights were also highly prone to water shortage; and paid a high cost for vendor-provided water in the inner-city slum. Regarding accessibility, 56.7% of the HHS were accessible within 0–15 m of paved road for inner-slum. Yet, only 2.8% of the HHS were accessible within 0–15 m of paved road for peri-urban. The graveness of road inaccessibility was elaborated by FHHS in peri-urban as follows:

I am a housewife. My husband is working in construction work. I lived in the hilly areas. I have to come up the hill Fetching water from Doro Erbata in the formal neighborhood. I have to send my Kids to School down the hill. When someone is ill or during pregnancy in the settlement where we lived, someone has to carry the person down the steep slope Near Mariam Church to the spot of the taxi center. So, road and transport inaccessibility are the critical problems affecting our daily life (Case study –5, 2018, Kolfe Keranyo Wereda 03 peri-urban)

Based on GIS service area analysis, 65.9% of HHS shall commute > 1.5 km to access primary school for peri-urban. 63.9% of the HHS shall commute > 3 km to access the health center for peri-urban. Yet, 100% of

⁶ Water Vulnerability inner-slum: one (No Vulnerability) =Own Piped Water Connection not shared at all, two (less Vulnerable) =Piped Water Connection shared by 2 to \leq 5 HHS, Three (Vulnerable) =Piped Water Connection shared by > 5 to \leq 10 HHS, Four (High Vulnerability) = Piped Water Connection shared by > 10 HHS or HHS use vendor-provided potable water. Five (Very High Vulnerable) =use Water from River or not potable water sources.

⁴ Formal employment considers those who depend on Government Employment, Private organization formal, and Self-employed Formal business.

⁵ The Derg regime ruled Ethiopia from 1974 to 1983.

inner-slum were accessible to education and health services by <1 and 1.2 km, respectively. The PPMC between primary school and health services was 0.878 for *peri-urban*. The correlation indicated that social services deprivations were increasing with increasing distance from the formal neighborhood for *peri-urban*.

4.4. Interrelationships of social with financial and physical capitals

There was a significant association between tenure status and CBO for *peri-urban* ($\chi^2 = 26.988$, $\alpha < 0.001$) and inner-slum ($\chi^2 = 25.117$, < 0.001). The association for *peri-urban* was due to 40.74% and > 78 % of renters from unauthorized dwellers, and the remaining tenure groups were involved in at least one CBO, respectively. The significant association for the inner-city slum was due to 50 %, and > 81 % of the unauthorized dwellers and the remaining de jure recognized tenure groups were involved in at least one CBO, respectively. An elderly woman, with de jure Kebele house tenure right, described that “Edir(CBO) members have participated and assisted me financially by reconstructing my demolished house beyond the assistance in case of death and illness” (Case study-6, 2018, Addis Ketema Wereda 07 inner-city slum). Yet, an unauthorized tenure right HHS mentioned that “Edir members assisted each other in case a person is ill and assisting families of the deceased not extending beyond this (Case Study-7, 2018, Addis Ketema Wereda 07 inner-city slum). The quantitative result coupled with the individual case study indicated that the extent of social capital is strong for de jure recognized tenure groups HHS in relative to unauthorized dwellers for inner-city slums. For *peri-urban*, renters from unauthorized dwellers were less involved in CBO.

There was a significant association between participation in the election of Kebele and tenure status for *peri-urban* ($\chi^2 = 36.376$, $\alpha = 0.001$). The above association was due to the combined low plus very-low election involvement was 51.9%, 28.6%, 21.8%, and 15.6% for HHS Rented From Unauthorized Dwellers, Peasant Authority Permission, Unauthorized Dwellers, and Owner Permit right/tax receipt, respectively. The insignificant association for the inner-city slum explained that tenure status does not reflect involvement in the election in the inner-city slum. The unauthorized dweller person in the inner-city slum described that “I have been contributing funds for development and participated in the Kebele election. Yet, we do not have legalized tenure rights. We feared that the government might evict us from the site that our children brought up” (Case study –8, 2018, Addis ketema Wereda 07 inner-city slum). The above view indicated that the unauthorized dwellers considered enhancing social capital as a means of accession to tenure rights. The unauthorized dweller in *peri-urban* mentioned that “she is participating in wereda election while the wereda or local administration did not collect fund as part of community contribution for development activities even if we are interested in contribution” (Case study –9, 2018, kolfe Keranyo Wereda 03 *peri-urban*). The above result indicated how the *peri-urban* unauthorized dwellers were excluded to contribute resources for development. There was a significant association between CBO versus income per AE for the inner-city slum ($\chi^2 = 12.21$, $\alpha = 0.007$). The association was due to 7.39 % and 23.53 % of HHS, who was not involved in CBO had income < 599 birr/M/AE and ≥ 3000 birr/M/AE, respectively. The above result indicated that low-income HHS had higher social capital and network as means of survival strategies in case of hardships.

4.5. Interrelationship of natural with human and financial capital

The overlaying of slope class with HHS GPS location screened the Vulnerable HHS. Accordingly, 50.8% of the HHS of *peri-urban* was living on slope > 20 percent, liable to flooding and landslides. For the inner-slum, 21.8 % of HHS were vulnerable to constraints of topography. The topography constraints were due to 20.3% of HHS located in 0–2% slope, liable for waterlogging and flooding, and 1.5% of HHS lived on a riverside slope, susceptible to flooding and landslides. The natural

capital (River) is highly contaminated with offending odor for inner-city slums, as most of the nearby river dwellers are disposing the toilets directly to the river. Based on GIS analysis, 38.9% of HHS of inner-slum were living within 50-meter distance from the river: - highly liable to offending smell and transmittable diseases. There was inverse PPMC ($r = -0.465$) between slope level and distance from the river for the inner-city slum implicated the combined vulnerability of nearby river HHS to landslide, flooding, and water contamination. There was a significant association between income per AE and housing location to hazard for the inner-city slum ($\chi^2 = 31.066$, $\alpha = 0.039$). The association for the inner-city slum was due to 60.23 % of HHS < absolute poverty line of Ethiopia. The dominant hazard for inner-city slum were flood/drainage problems. For *peri-urban*, 97.6 % of HHS were prone to hazard regardless of income. The most prevailing natural hazards for *peri-urban* were flood/landslide-related.

4.6. The capability and Institutional aspects

4.6.1. Institutional aspects

Peri-urban and Inner-city slum: the key institutions directly working on job creation and poverty alleviations in *peri-urban* and inner-city slums were Job creation & Enterprise office (job creation & fund), Women and Children Affairs Office (jobs for women), Labor and Social Affairs office (registering unemployed person), Solid Waste Management Office(waste collection/sorting), Urban Productive Safety Net Program Office (UPSNP) (relief assistance and protect livelihoods) and Community Mobilization Office (participation and job creation in infrastructure projects) and construction office (job in construction and infrastructure) (T. Getu, personal communication, October 22, 2021) and (A.Ketsela, personal communication, October 28, 2021).

Inner-city slum: the local administrative office worked with private organizations /associations (Addis credit and saving, Consumers, handicraft, dwellers forums, Addis Capital (lending machinery). Non-Government Organizations (NGO) partnered with the local administrative office were Afro Health, Dawit Dreams, amref Health Africa / CCF, New Integrated Development Enterprises. The local administrative office worked in partnership with the civic society associations (youth league, women league, disabled, dwellers forum, condominium) for poverty alleviations and public mobilizations. The local administrative office has a more decentralized administrative structure devolved from Wereda- Ketena- Block unit- HHS unit (A.Ketsela, personal communication, October 28, 2021). The decentralized nature of the structure is crucial to work closer to the people and ensure efficient service delivery and realize safety/security. The NGOs complemented government work by bridging the gap of training UPSNP beneficiaries and addressing the needs of disabled and vulnerable women (S. Bogale, personal communication, November 3, 2021). The social and institutional capital accumulation is higher for the inner-city slum relative to *peri-urban*, due to an array of actors (CBO, Private, NGO’s and civic society associations) involved. The allowed building permit regulation is mostly G + 7 and prohibited upgrading housing from substandard to standard materials (D. Abera, personal communication, January 15, 2018) that deter the capability of physical asset accumulation for the urban poor.

Peri-urban: CBO, recognized in the local organizational structure, played a role in maintaining houses of the vulnerable (the poorest of the poor, the disabled, and the elders) and availing educational facilities for chronically poor students. The local administrative office did not work with civic society associations (Women and Youth league) and NGOs (T. Getu, personal communication, October 22, 2021). The insignificant social and institutional capital obscured the crucial role of gender and youth in enhancing livelihood capitals. The NGOs, as well as Multilateral / Bilateral agencies, are involved less in poverty alleviations. The World Bank assisted programs of MSSE (Micro and Small Scale Enterprise) and UPSNP. The local administrative office has devolved the organizational structure from the Wereda-Ketena-block level for mobilizing development activities and ensuring safety/security (S. Eyassu, personal

communication, October 20, 2021). Currently, the farmers in *peri-urban* have de jure tenure rights that dwindle informal land transactions. Yet, informal settlers who acquired land through agricultural land transactions are subject to a coercive measure of bulldozing, stripping homeownership (M. Birhan, personal communication, October 20, 2021), which created double standard in tenure ownership right.

4.6.1. Capability aspects

Inner-city slum The potential capability functioning (individuals and collective) for livelihood capital accumulations is sounding due to the diversity of partners working in the government, non-government, private, and civic society relative to *peri-urban*. Yet, the wereda administration did not authenticate and work with CBO despite 90.3 % of HHS being CBO members. The government leveraged the individual capability in MSSE to be able and meet opportunities through a revolving fund. Yet, capital injection for micro-finance quitted currently due to failure to execute payment by previous beneficiaries. The above situation stunted the future development of micro-finance and functioning individual capability at the expected level. The earlier MSSEs' were exemplary and created livelihood capital accumulation through jobs creation for others. Yet, some MSSEs formulated by mobilizing their capitals while the poor did not have the initial cash to formulate MSSE. The current functional credit institution (Addis Credit and Loan association) interest rate is unaffordable (18 %) for the poor for engaging in the business of their capability functioning. Addis capital goods & finance business provide asset-based lending after the MSSE's beneficiaries pay 15 % of the machinery cost (A. Ketsela, personal communication, October 28, 2021).

Current research indicated that 58 % of the wereda HHS were not self-sufficient in food-one of the poorest areas of AA. UPSNP program benefitted all the target groups in the 1st and 2nd rounds (T.Bayu, personal communication, October 29, 2021). Since the area is closer to the CBD, the poor and vulnerable dwellers survived through diversifying their income sources by renting beds or houses and opening small businesses near their dwellings (E.Bayessa, personal communication, November 5, 2021). Under UPSNP, the beneficiaries participated in development activities through relief food assistance, compulsory saving of 1/5th of earning as a guarantee for graduation, took training (financial, work culture, and technical), and the UPSNP also assisted in diversifying their income sources portfolio. After three years of graduation, 500 USD granted plus 36 months 20 % income saving + additional income opportunity saving for MSSE) and become micro-finance clients involved in the business functioning their capability. The major problems faced in UPSNP executions were screening beneficiaries, not engagement in diversified business, and the syndrome of expecting assistance after graduation (T.Bayeu, personal communication, October 29, 2021). The participation office worked with offices such as UPSNP, job opportunity enterprise office, Construction, and Finance. The dwellers' contributed 65 % of the project cost, matched with a 35 % government share for infrastructure projects. The participatory-based cobblestone road and drainage projects generated job opportunities for the jobless and opportunities for the dwellers to participate in finance and labor. In general, projects executed by the participation office for 2020/21 through public mobilization were a public toilet, public kitchen, Culvert, public shower, cobble maintenance, new and maintenance ditch and drainage work, police center, bridge maintenance, green development, and street light. Based on Wereda 07 administrative office, the project executions of the local administration office against planned for 2020/21 were financial (18.1%), knowledge and skill (10.7 %), labor(9.5%), and material (12.9 %).

Peri-urban : the structure and process to transform assets for livelihood capital asset accumulations are not satisfactorily due to fewer institutions involved in livelihood capital accumulation and the functioning of capability. The wereda administration office tied poverty alleviation effort with income injection through the UPSNP program and the previous revolving fund of MSSE. Edir (the only accredited CBO in

the local administrative structure) engaged in maintaining houses of chronically poor and availing educational facilities for students of an impoverished families. Yet, the wereda administration did not induce a commendable effort to partner with multilateral/ bilateral agencies and civic society associations for capability functioning to ensure livelihood capital accumulation. No NGO is replicating the reputable experience on management of MSSE and poverty alleviations (T. Getu, personal communication, October 22, 2021). The process of leveraging community capacity to build the livelihood capitals assets is rudimentary. The Wereda administrative office facilitated the formulation of MSSE, members' fund allocation, and job choice commensurate with capability. The wereda administrative office equipped the beneficiaries with financial management skills, developing trust among members, and strengthening the sustenance of MSSE (G. Bihonegn, personal communication, October 24, 2021). The Wereda job creation and entrepreneurship office quit providing credit for MSSE establishments after 2017 due to unpaid arrears of credit by beneficiaries. Currently, the participation of the unemployed youth on MSSE has shown declining trends. Yet, some people formulated MSSE through assembling their financial resources (W. Getu, personal communication, November 1, 2021). The quitting of financial capital injection also affected the accumulation of human and physical capital of MSSE for poverty alleviation efforts that provide lessons regarding the necessity of AB policy.

Based on the HHS survey, 36 % of the wereda dwellers were not self-sufficient in food. According to UPSNP, the vulnerable dwellers (formal + informal) obtained food relief assistance through investing their capability to leverage livelihood capital assets. UPSNP program benefitted the poor and poorest of the poor in five years stretch period, focusing on the functioning of people's capability. The beneficiaries of UPSNP participated in livelihood capital asset accumulations through engaging in Solid waste collection and sorting, beautification and greenery, soil and water conservation, gully rehabilitation, road infrastructure, urban agriculture. The procedures of graduation of chronically poor HHS involved in UPSNP are similar to the inner-city slum. A reasonable number of the UPSNP beneficiaries showed commendable outputs in the urban agriculture sector (T. Solomon, personal communication, October 21, 2021). The contribution for infrastructure projects is 65 % and 35 % from dwellers and government, respectively. Yet, the wereda administrative office excluded informal settlement dwellers to contribute 35 % of resources for public work projects. The public participatory projects executed in the year 2020/21 were cobblestone roads, open ditches, drainages, and street lights (A. Yakem, personal communication, October 25, 2021).

4.7. Risks and vulnerabilities

Peri-urban: the main environmental risks are degradation of hilly and other areas and liability to gully erosion and flooding (T. Anteneh, personal communication, October 21, 2021). UPSNP included in the program the addressing of the above environmental issues. Based on a 2018 survey, 82.1 % of the HHS claimed that the main hazards were steep slopes and flooding. The security and safety risks are personal fights, robbery, burglary, and land invasions (T. Kuma, personal communication, October 28, 2021). According to Kolfe Keranyo Werda 03 health office for 2020/21, the top four leading causes of morbidity were: respiratory tract infection, urinary tract infection, inability to swallow, and tonsillitis.

Inner-city slum: the main environmental risks were overcrowding/ congestion, waste disposal, sanitation problems, and shortage of green space (F.Zeleke and Amedmariam. H, personal communication, November 1, 2021). Based on the 2018 socio-economic survey, 47 % of HHS claimed no hazard in the neighborhood, 21.8 % (flood and drainage problems), 6.7 % (toilet excreta smell/overflow), and 6.4 % (near a polluted river). The type of security and safety risks includes robbery, personal fights, burglary, gambling, and illegal houses of shisha smoking and chat chewing (T.Eshetu, personal communication,

November 5, 2021). According to Addis Ketema Addis Raey Health Station, the top four leading causes of morbidity for 2020/21 were Urinary tract infection, medical certificate issue, Diarrhea, and head injury (due to crime and fight).

5. Discussion

The study used explanatory sequential design primarily analyzing through quantitative research for refining strategic issues for ABS interventions that relate to many aspects of livelihood capital assets deprivations, considering the variation of vulnerability sub-groups. Then, the qualitative individual case study reflected the depth of dwellers' impression on their livelihood capital assets deprivations. The key-informants interview analyzed the institutional, capability, and safety/risk issues. The triangulation of quantitative with qualitative information provided a comprehensive picture for validating the facts for ABS recommendations. There is an interrelationship among livelihood capital assets following authors (Farrington et al., 2002; Sheilah et al., 2001; UNDP 2017). The more livelihood capital assets deprivations, the more likely the HHS risks and vulnerabilities following Lienert and Burger (2015). Financial capital is one of the crucial assets for capital accumulation and livelihood strategies in line with the author's (Wang et al., 2021a) argument. Urban areas relied on a cash economy for food (61.36% and 55.8% for the inner-city slum and *peri*-urban, respectively). The *peri*-urban settlers spent higher on water, transport, and energy for cooking (< 9%) as compared with inner-city slum residents (< 5 percent) due to social exclusion and non-integration with the mainstream of urban development. The above findings indicated financial capital (cash, credit, and subsidy) is a strategic issue for livelihood capital assets accumulation. The reliance on cash economy for food, water, transport, and consumables justified the underestimation of urban poverty relative to rural conformed with authors (Mitolin & Satterthwaite, 2004; World Bank, 2015b) argument. The findings of the inner-city slum revealed income deprivation is associated with overcrowding, poor sanitation, sub-standard housing floor materials, and poor building quality. For *peri*-urban, income deprivation is associated with going long distances for water fetching, low water consumption, low mobility, low parcel per capita, poor building wall material, and poor building conditions.

Regarding the interconnections within human capital, there is a difference in access to human capital by gender and educational status. Gender and income do not show significant association in informal settlements conform to Jayamohan and Amenu (2014) argument. Yet, regarding human capital, women are deprived in occupation (85% of HHS depended on assistance were widowed FHHS in the inner-city slum) and educational status (2.15 and 1.77 illiterate FHHS for every MHHS for inner-city slum and *peri*-urban, respectively). The vulnerability of the old age HHS to poverty interfaces with the author's (Aboderin et al., 2017) arguments for an age-friendly slum initiative as the older people are co-habiting with and caring for children. The overall Unemployment rate of the inner-city slums (33.71%) exceeded the unemployment rate of 28.6% for 15–64 age groups of AA (CSA, 2015). Moreover, the youth unemployment percentage was associated with the education status of grades 9–10 for the two informal settlement areas ($r \geq 0.3$). The unemployment findings conform to FDRE (2018) that implicated creating job opportunities for youths of secondary education level. Unemployment is a strategic issue since a higher unemployment rate is significantly associated with overcrowded living conditions, low educational status, and low income. Moreover, the poor HHS education status leads to family members' poor education in line with the culture of poverty theory of Lewis (1966). The lesson is poverty alleviation programs shall enhance the class-consciousness of parents of low education levels through informal/adult education as it is a strategic issue. Over-crowdedness is the strategic issue in the inner-city slums; related to low income, unemployment rate, and poor sanitation. Hence, overcrowding is the survival strategy for diversifying sources of financial

capital by the inner-city slum dwellers based on key informant interview findings and the quantitative information (39.3% of HHS survived through renting beds). The above situation depicts Alonso-Muth's Mills bid rent model argued by UN-Habitat (2003) that the poor outbid the rich for CBD through overcrowding, renting and reducing mobility. (Figs. 1 and 2).

Tenure security is the strategic entry point for livelihood capital accumulations due to a link between SDG goal-1 on poverty reduction with goal-11 indicators of addressing inadequate housing and access to land in line with SDG Tracker (2019). Tenure insecure HHS in the inner-city slum is vulnerable to poor sanitation, poor water access, and low income. Most HHS in *peri*-urban (82%) were tenure insecure and associated with poor sanitation services. The inner-city slum and *peri*-urban findings indicated the association between tenure security levels and CBO (community bargaining potential). Therefore, asset accession through tenure security is the strategic entry point for capital accumulation through unlocking dead capital and bargaining means for credit, collateral, and service provision in line with authors (Dani & Moser, 2008; De Soto, 2001; Fontana, 2016). The legally recognized tenure groups (permit rights holders and Kebele renters) in the inner-city slum rented their house for exorbitant prices relative to the very-low rental price paid by Kebele renters to formal Kebele administration. Full titling (non-incremental regularization) could lead to exorbitant rent for renters and market-based eviction for owners (transacting property for a better price) due to neighborhood improvements conforming with authors (Payne et al., 2009) arguments. Group and occupancy tenure right provision for HHS who do not have tenure right pave the way for incremental regularization to lease or other forms of right in the future, as articulated in Payne et al. (2009).

The poor HHS in the inner-city slum that dwell in the edges of watercourses and on the sides of steep slopes tend to be more vulnerable to a lack of mainstream infrastructure and services (road access, sanitation, water, drainage) in general. In addition, they are also vulnerable to environmental hazards (recurrent floods, landslides, toilet overflow, poor refuse collection, water pollution, transmitted diseases, and so on) and crime (safety and security). In addition to suffering from similar problems to a considerable degree, *peri*-urban HHS lives in high slope and marginalized areas lacking critical infrastructure (motorable roads, water mains, power and communication grids, health facilities, and shopping services) and are liable to crime. The asset derived from natural capital (the river), for the inner-city slum, is polluted with human waste and excreta through direct toilet connection that adversely affects the health of human capital. The *peri*-urban squatters live on risky steep slopes, exposed to flooding and landslide hazards. In general, to accumulate livelihood capitals for poverty alleviations, informal settlement areas needs interventions to enhance the resilience capacity of the residents to disaster, economic shock, and stress.

The *Peri*-urban institutions used meager social capital (not recognized civic society associations except CBO) and other institutions (not partner with private organizations and NGOs) for accessing livelihood capital assets for the poor and vulnerable sub-groups. The inner-city slum institutions relatively mobilized the potentials of human capital assets by formulating civic society associations, NGOs, and private organizations while failing to utilize CBO for livelihood capital asset accumulation. The inaccessibility of enabling institutions and social capitals to enhance their asset base, especially pronounced in *peri*-urban, exacerbate poverty, bring social injustice, limit access to credit and labor for the poor in light of authors (Bebbington, n.d; Shahbaz, Vinod, Geiser, Sadaf, Schärer, & Müller-Böker, 2010; UNDP 2017) argument. The imposition of high-standard building permit regulation (mostly G + 7) on the inner-city slum eroded the livelihood capital accumulation and valorization for the poor through incremental housing improvement. For *peri*-urban, the government recognized de jure tenure right for farmers while excluding HHS who bought land from farmers that contravene the global trends of leaving no one behind in informal settlement regularization and upgrading following UN-Habitat. (2020b).

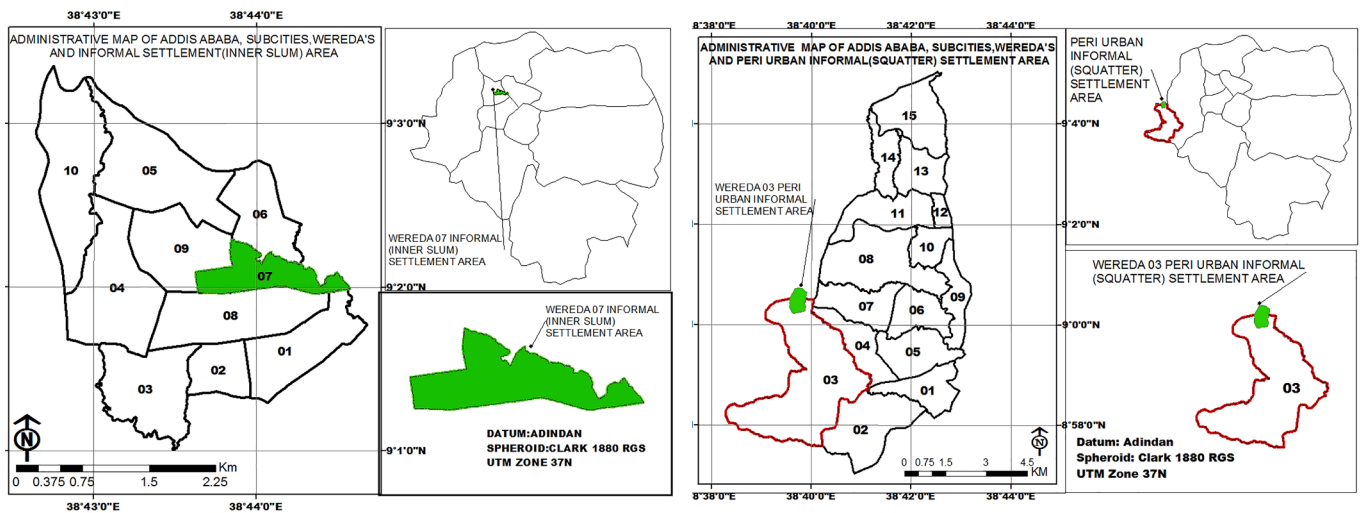


Fig. 1. Figure-1: The location of Wereda 07 case study area in relative to Addis-Ketema sub-city and Addis Ababa city (left) and Figure-2: the location of Wereda 03 case study area relative to Kolfe-Keranyo sub-city and Addis Ababa city (right).

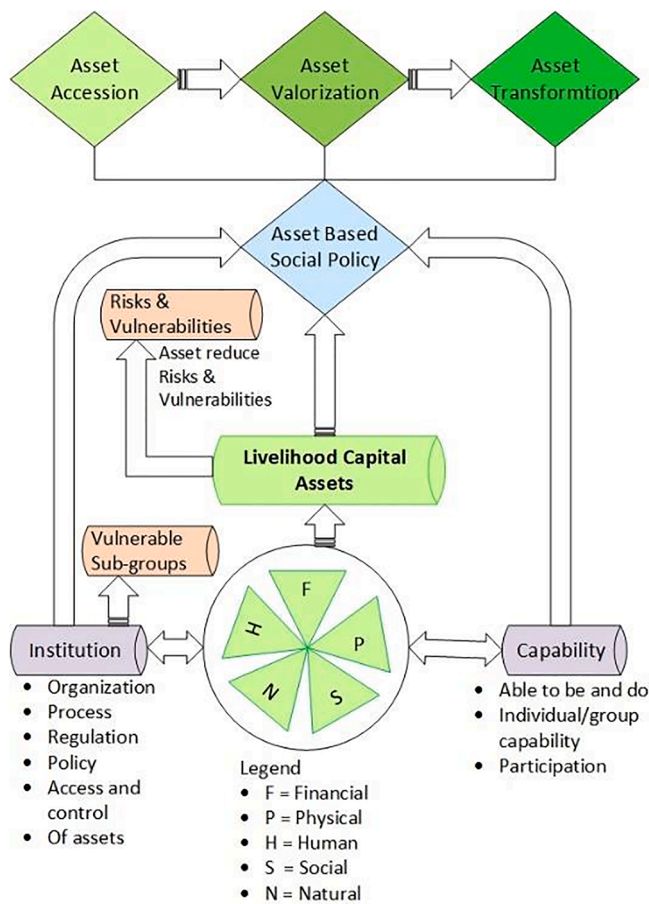


Fig. 2. Conceptual framework of the paper.

The government enhanced the job creation capability of the unemployed and the functioning of capability through MSSE development, revolving funds (the inner-city slum and *peri*-urban), and asset-based lending initiation for machinery (inner-city slum). Traditional collateral funding poses a challenge for the financial recovery of firms and the sustained functioning of capability. Therefore, expansion of asset-based lending and a special fund allotment for MSSE are the alternative options in line with authors (Nega & Edris, 2016), backed with training,

diverse sources of financing MSSE, and a robust management system for revolving fund recovery.

The inner-city slum has relatively better capability functioning considering the mobilized social and human livelihood capital assets in relative to *peri*-urban following the authors' (Lienert & Burger, 2015) argument regarding asset and capability. UPSNP contributed to asset accumulation by involving the poor in public works, reducing environmental risks, enhancing saving, creditworthiness, upgrading individual skills, and involving the beneficiaries in work they are able to be and do and capital accession. UPSNP shall be sustainable to realize asset consolidation for the chronic poor population through integrating revolving funds injection, low-interest rates, asset-based lending, and tenure security. Moreover, urban development policy and strategies need revisiting and fine-tuning to chronically poor following Kassahun and Tiwari (2012). Yet, in general, informal settlements required addressing capability deprivations and accessing vulnerable sub-groups with livelihood capitals through mobilization of the community, civic society, and other partner institutions following authors (Bebbington, n. d; Dani & Moser, 2008; Sen, 1995; Serrat, 2017; Shahbaz et al., 2010; UNDP, 2017) argument. The new trend in social policy shall bring transformational change through the principle of universal, inclusive, integrative, partnership and aligned to global/regional social policy following United Nations (2021).

6. Conclusions and recommendations

The interrelationships between livelihood capital assets deprivations and the variations of deprivations by sub-groups emanated strategic issues (issues related with multifaceted deprivations) for ABS policy. To sum up, the constraint of asset accumulations, poorly functioning individual and collective capability, and the lack of strong institutions that bring livelihood capital assets claim closer to the poor and vulnerable sub-groups degraded the social wellbeing of poor people in informal settlements. Accordingly, ABS policy (asset accession, asset valorization and asset transformation) is recommended basing the critical role played by asset, capability and institution in improvement of well being as indicated on table-1 below.

Ethical statement

The journal I published complied with Ethical statement. I am confident that it is free from misconduct and plagiarism. The journal can perform any kinds of software check for plagiarism and search through

misconduct statement (if any). It is authentic work and original research to the best of my knowledge. I am ready to respect the ethical standards of the journal and COPE guideline on plagiarism to be practical. I am also abide by the rule of the journal for peer-reviewed (double-blind).

CRedit authorship contribution statement

Gizachew Berhanu: Writing – original draft, Methodology, Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Visualization. **Solomon Mulugeta:** Supervision, Methodology, Validation, Writing – review & editing. **Ephrem Gebremariam:** Supervision, Methodology, Validation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.resglo.2022.100081>.

References

- Abiy, M. (2020). *Urban Productive Safety Net Program Contribution to Beneficiary Household (S) Food Security: A Case of Woreda Seven, Kirkos Sub City*. Addis Ababa: Addis Ababa University.
- Aboderin, I., Kano, M., & Owil, H. A. (2017). Towards “Age-friendly” Slums? Health Challenges of Older Slum Dwellers in Nairobi and the Applicability of the Age-friendly City Approach. *International Journal of Environmental Research and Public Health*, *14*(1259), 1–13. <https://doi.org/10.3390/ijerph14101259>
- Abrams, C. (1966). *Man's Struggle for Shelter in an Urbanizing World*. Boston: the MIT press Classic Series.
- Arroyo, L. (2013). *Organized self-help housing as an enabling shelter & development strategy: Lessons from current practice, institutional approaches, and projects in developing countries*. Lund, Sweden: Lund University.
- Baud, I., Sridharan, N., & Karin, P. (2008). Mapping Urban Poverty for Local Governance in an Indian Mega-City: The Case of Delhi. *Urban Studies* *45*(7), 1385–1412. Retrieved from <https://doi.org/10.1177/0042098008090679>.
- Bebbington, A. (n.d.). *Capitals and Capabilities: A framework for analyzing peasant viability, rural Livelihoods, and poverty in the Andes*. London: International Institute for Environment and Development.
- Carloni, A. S., & Crowley, E. (2005). *Rapid guide for missions Analysing local institutions and livelihoods Guidelines*. Rome: Food and Agriculture Organization of The United Nations.
- Caroline, O., & Moser, N. (2006). *Asset Based Approaches to Poverty Reduction in a Globalized Context: An introduction to asset accumulation policy and summary of Workshop Findings*. Global Economy and Development Working Paper, pp. 1–39.
- CSA(Central Statistics Agency of Ethiopia). (2007). *Summary and Statistical Report of the 2007 Population and Housing Census: Population Size by Age and Sex*. Addis Ababa: Population Census Commission.
- CSA. (2013a). *Population Projection of Ethiopia for all regions at Wereda Level from 2014–2017*. Addis Ababa: Central Statistics Agency.
- Csa. (2013b). *Population projection for Ethiopia 2007–2037*. Addis Ababa: Central Statistics Agency.
- Csa. (2015). *Urban Unemployment Survey*. Addis Ababa: Central Statistics Agency.
- Dani, A. A., & Moser, C. (2008). *Asset-Based Social Policy and Public Action in a Polycentric World*. In C. Moser, & A. A. Dani (Eds.), *Assets, Livelihoods and Social Policy* (pp. 3–41). Washington, DC: New Frontiers of Social Policy, The World Bank.
- De Soto, H. (2001). *The mystery of Capital*. In F. Edesio (Ed.), *The Influence of De Soto's The Mystery of Capital*. London: Bantam Press.
- Ding, W., Jimoh, S. O., Hou, Y., Hou, X., & Zhang, W. (2018). Influence of Livelihood Capitals on Livelihood Strategies of Herdsmen in Inner Mongolia, China. *Sustainability*, *10*, 3325. <https://doi.org/10.3390/su10093325>
- ECE (Economic Commission for Europe). (2008). *In-search for Sustainable Solutions for Informal Settlements in the ECE Regions: Challenges and Policy Responses*. Geneva: ECE.
- Elias, Y. A. (2008). *Revealing Slums. Revealing Responses: Urban Upgrading in Tenant Dominated Inner City Settlements*. Trondheim: Norwegian University of Science and Technology.
- Eckstein, S. (1990). Urbanization revisited: Inner-city slum of hope and squatter settlement of despair. *World Development*, 165–181.
- Farrington, J., Ramasut, T., & Walker, J. (2002). *Sustainable Livelihood Approaches in Urban Areas: General Lessons, with Illustration from Indian cases Cities*. Stockholm: Swedish International Development Cooperation Agency.
- Federal Democratic Republic of Ethiopia (FDRE). (2018). *Enhancing Economic Development and Job Creation in Addis Ababa: The Role of the City Administration*. Danvers: World Bank.
- Fontana, C. (2016). Hernando de Soto on Land Titling: Consensus and Criticism. *Next Generation Planning*, *3*, 36–48. <https://doi.org/10.24306/plnxt.2016.03.003>
- Gebresilassie, H. Y. (2019). *Ethiopia's Urban Productive Safety Net Programme: Its Impact on Households' Food Insecurity*. Unpublished manuscript. Adigrat: Adigrat University.
- Graciela Tonon (2018) *Communities and Capabilities*, *Journal of Human Development and Capabilities*, *19*:2, 121–125, DOI: 10.1080/19452829.2018.1454288.
- Jayamohan, M. K., & Amenu, T. K. (2014). Gender and Poverty-An Analysis of Urban Poverty in Ethiopia. *Development Studies Research*, 233–243. <https://doi.org/10.1080/21665095.2014.917053>
- Jones, P. (2017). Formalizing the Informal: Understanding the Position of Informal Settlements and Slums in Sustainable Urbanization Policies and Strategies in Bandung. *Indonesia. Sustainability*, *9*(8), 1436. <https://doi.org/10.3390/su9081436>
- Kassahun, S. (2010). Urbanization and its impact on the Making of Informal Settlements in Addis Ababa. In J. Fransen, S. Kassahun, & M. Van Dijk (Eds.), *Formalization and in formalization Process in Urban Ethiopia: Incorporating Informality* (pp. 71–83). Maastricht: SHAKER Publishing.
- Kassahun, S., & Tiwari, A. (2012). Urban Development in Ethiopia: Challenges and Policy Responses. *The IUP Journal of Governance and Public Policy*, *7*(1), 60–75.
- Kloosterboer, M. H. (2019). The ‘New Addis Ababa’: Shanty Town or Global City? An Assessment of Large-Scale Inner-City Renewal, Redevelopment and Displacement for the Construction of ‘New Addis Ababa’. Glasgow: University of Glasgow, Ph.D. Thesis Urban Studies.
- Lakisha, D. T. (2012). *Towards Practical Guidelines for the design of affordable, net Zero Communities in Peri-Urban Ethiopia*. Greensboro: The Associate School of Construction.
- Levitas, R. (2006). *The concept and Measurement of Social Exclusion*. Bristol: Policy Press.
- Lewis, O. (1966). The Culture of Poverty. Retrieved from *Scientific American*, *215*(4), 19–25 <https://www.jstor.org/stable/24931078>.
- Lienert, J., & Burger, P. (2015). Merging capabilities and livelihoods: Analyzing the use of biological resources to improve well-being. Retrieved from *Ecology and Society*, *20* (2) <https://www.jstor.org/stable/26270215>.
- Messer, N., & Townsley, P. (2003). *Local Institutions And Livelihoods: Guidelines for Analysis*. Rome: Food and Agriculture Organization of The United Nations.
- Mezgebo, TG. (2021). “Urbanization and Development: Policy Issues, Trends and Prospects”. In Mengistu K. and Getachew D. (Ed), *State of the Ethiopian Economy 2020/2021: Economic Development, Population Dynamics and Welfare*, Addis Ababa: Ethiopian Economic Association.
- Ministry of Federal Affairs. (2005). *Urban Development Policy: Approved by Council of Ministers*. Addis Ababa: Ministry of Federal Affairs.
- Minwuyelet, M. (2005). *City Expansion, Peri-urban Settlements and Policy Implications in Addis Ababa: The Case of Kolfe-Keranyo Sub-city*. Working Paper on Population and Land Use Change in Central Ethiopia, nr. 2, Acta Geographica-Trondheim, 2-28.
- Ministry of Labor and Social Affairs. (2009). *National Employment Policy and Strategy of Ethiopia*. Addis Ababa: The National Employment Council.
- Ministry of Urban Development and Housing. (2003). *Urban Land Development and Management Policy*. Addis Ababa: Ministry of Urban Development, Housing, and Construction.
- Mitilini, D., & Satterthwaite, D. (2004). *Empowering Squatter Citizen and Urban Poverty Reduction*. London: Earth scan, WWF-UK & International Institute for Environment and Development.
- Moser, C. (2008). *Asset and Livelihood: A framework for Asset Based Social policy*. In I. A. Dani, & C. Moser (Eds.), *Asset, Livelihood and Social Policy* (pp. 43–81). Washington, DC: New Frontiers of Social Policy, The World Bank.
- Moser, C., & Dani, A. A. (2008). *Assets, Livelihoods and Social Policy*. Washington DC: World Bank Group Doi: 10.1596/978-0-8213-6995-1.
- Nega, F., & Edris, H. (2016, February). *Small and Medium Enterprise Access to Finance in Ethiopia: Synthesis of Demand and Supply*. The Horn Economic and Social Policy Institute (HESPI) Working Paper 01/16, pp. 1–39.
- National Planning Commission of Ethiopia. (2017). *Ethiopia's Progress Towards Eradicating Poverty: An Interim Report on 2015/16 Poverty Analysis Study*. Addis Ababa: National Planning Commission.
- Payne, G., Rakodi, C., & Durand-Lasserve, A. (2009). The limits of Land Titling and Home Ownership. *Environment and Urbanization*, *21*(443), 443–462. <https://doi.org/10.1177/0956247809344364>
- PDC (Planning and Development Commission).. (2020). *10-years Development Plan: A Path Way to Prosperity 2021–2030*. Addis Ababa: Planning and Development Commission, Federal Democratic Republic of Ethiopia.
- Rebolj, B. A. (2013). The Case Study as a Type of Qualitative Research. *Journal of Contemporary Educational Studies*, *1*, 28–43.

- Robeyns, I., & Morten, B. F. (2021). The Capability Approach, The Stanford Encyclopedia of Philosophy. In N. Edward, Encyclopedia of Philosophy. Winter. <https://plato.stanford.edu/archives/win2021/entries/capability-approach/>.
- Sen, A. (1995). *The Political Economy of Targeting: Public Spending and The poor*. Washington DC: D. van de Walle and K. Nead.
- Serrat, O. (2017). Knowledge Solutions: Tools, Methods, Approaches to Drive Organizational Performance. Singapore: Springer. DOI: 10.1007/978-981-10-0983-9.
- Shahbaz, B., Vinod, P. C., Geiser, U., Sadaf, T., Schärer, L., & Müller-Böker, U. (2010). Access to Livelihood Assets: Insights from South Asia How Institutions Work. In H. Hurni, U. Wiesmann, & w. I. Co-editors, Global Change and Sustainable Development: A Synthesis of Regional Experiences from Research Partnerships (pp. 283-297). Bern, Switzerland: Perspectives of the Swiss National Centre of Competence in Research (NCCR) North-South, University of Bern Vol.5.
- SDG Tracker. (2019). Sustainable Development Goals/Sustainable Cities and Communities. Retrieved from Sustainable Development Goals/Sustainable Cities and Communities: <http://sdg-tracker.org/cities>.
- Sheilah, M., Tamsin, R., & Julian, W. (2001). Sustainable Urban Livelihoods: Concepts and Implications for policy. Retrieved from No. 112. Sustainable Urban Livelihoods: Concepts and Implications for policy. https://www.ucl.ac.uk/.../DPU_Meikle_Sustainable_Urban%20Livelihoods.pdf. Accessed 17 August 2019.
- Shinns, L., & Lyne, M. (2002). Symptoms of Poverty within a Group of Land reform Beneficiaries in the Midlands of KwaZulu Natal: Analysis and Policy Recommendations. In T. Ephrem, Livelihood and Food Security in the Small Urban Centers of Ethiopia: The case of Durame, Welenchiti and Debresina Towns. Addis Ababa: Ph.D. Thesis, Addis Ababa University.
- Solomon, M., & Mcleod, R. (2004). Feasibility Study for the Application of Community-Led Infrastructure Finance Facility Operations in Ethiopia. In: A. Y. Elias, Revisiting Slums, Revealing Responses: Homeless International.
- Soma, H., Sukhwani, V., & Shaw, R. (2020). An approach to determining the linkage between livelihood assets and the housing conditions in urban slums of Dhaka. *Journal of Urban Management*. <https://doi.org/10.1016/j.jum.2021.08.006>
- Stoke, C. J. (1962). A theory of Slum: Land Economics. In A. Gossaye, Inner City renewal in Addis Ababa: The Impact of Resettlement on Socio-Economic and Housing Situations of Low Income Residents (pp. 187-197). Trondheim: Land Economics Vol.38. No.3,187-197.
- Turner, J. C. (1982). Issue on Self Help and Self-Managed Housing. From Ward P. M Self Help Housing, a Critic, Mansell, 99-113.
- UNDP. (2012). High level political forum on sustainable development. <https://sustainabledevelopment.un.org>.
- UNDP. (2017). Application of the Sustainable Livelihood Frameworks in Development projects. Panama City: United Nations Development Program(UNDP). Retrieved from file:///C:/Users/User/Downloads/UNDP_RBLAC_Livelihoods%20Guidance%20Note_EN-210July2017.pdf.
- UN-Habitat. (2003). The Challenge of Slums: Global Report on Human Settlements 2003. London and Sterling, VA: Earthscan Publications Ltd <https://www.un.org/ruleoflaw/files/Challenge%20of%20Slums.pdf>.
- UN-Habitat.. (2011). *Condominium Housing in Ethiopia: The Integrated Housing Development Program*. Nairobi, Kenya: UN-Habitat.
- UN-Habitat.. (2014). *Structural Transformation in Ethiopia: The Urban Dimension*. Nairobi: UN-Habitat.
- UN-Habitat. (2020a). Urbanization and Cities: Trends of New Global Force. Retrieved from Urbanization and Cities: Trends of New Global Force: https://unhabitat.org/sites/default/files/2020/10/chapter_1_urbanization_and_cities.pdf.
- UN-Habitat.. (2020b). *Caribbean Strategy for Informal Settlement Upgrading: A Guide to Inclusive and Resilient Urbanization*. Nairobi: UN-Habitat.
- United Nations. (2021, December). New trends and Innovations in Social Policy. Retrieved from United Nations Library: <https://doi.org/10.18356/626edf75-en>.
- Vatsa, K. (2004). Risk, Vulnerability, and Asset-Based Approach to Disaster Risk Management. *International Journal of Sociology and Social Policy*, 1–48. <https://doi.org/10.1108/01443330410791055>
- Walker, C., & Baxter, J. (2019). Method Sequence and Dominance in Mixed Methods Research: A Case Study of the Social Acceptance of Wind Energy Literature. *International Journal of Qualitative Methods*, 1–14. <https://doi.org/10.1017/CBO9781139227193>
- Wang, M., Li , M., Jin, B., Yao, L., & Ji, H. (2021a). Does Livelihood Capital Influence the Livelihood Strategy of Herdsmen? Evidence from Western China. *Land* 10,763. Retrieved from Doi: 10.3390/land10070763.
- Wang, W., Lan, Y., & Wang, X. (2021b). Impact of livelihood capital endowment on poverty alleviation of households under rural land consolidation. *Land Use Policy*. <https://doi.org/10.1016/j.landusepol.2021.105608>
- World Bank. (2015a). *Ethiopian Urbanization Review: Urban Institutions for Middle Income Ethiopia*. UN-Habitat, *the State of Addis Ababa*. Washington D. C: World Bank.
- World Bank. (2015b). Ethiopia Poverty Assessment 2014: Poverty Global Practice African Region. World Bank Group. Retrieved from <http://documents1.worldbank.org/curated/en/131011468247457565/pdf/AUS67440REVISE0essment0pub02020015.pdf>.
- World Bank. (2016). *Background Report on Urban Land use Planning and Development for Land Governance Assessment Framework Implementation in Ethiopia: Panel 3 Gizachew Berhanu*. Addis Ababa: World Bank.
- Yamane, T. (1967). *Statistics, An Introductory Analysis* (2nd Ed). New York: Harper and Row.
- Zafu, A., & Peter, N. (2014). *Older Slum in Addis Ababa, Ethiopia: How do they work? ARCHCAIRO 2014: Responsive Urbanism in Informal Areas, 6th International Conference* (pp. 514–525). Perth, Australia: Curtin University.