CENTER FOR RURAL LIVELIHOOD & DEVELOPMENT STUDIES
COLLEGE OF DEVELOPMENT STUDIES
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IMPACT OF SMALL-SCALE IRRIGATION ON HOUSEHOLD MULTIDIMENSIONAL POVERTY IN BAHIR DAR ZURIA WOREDA, NORTH WEST ETHIOPIA

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Impact of Small-Scale Irrigation on Household Multidimensional Poverty in Bahir Dar Zuria Woreda, North West Ethiopia

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Statement of the Author

I, Mulugeta Temesgen, confirm that, this final thesis submitted to the Center for Rural Development Studies, College of Development Studies, Addis Ababa University is prepared and it has not been submitted to other academic institutions. This is to acknowledge that, the information indicated in this final thesis is my own work.

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Acronyms

ATE	-	Average Treatment Effect
FAO	-	Food and Agricultural Organization
GDP	-	Gross Domestic Product
IFAD	-	International Fund for Agricultural Development
NBE	-	National Bank of Ethiopia
PSM	-	Propensity Score Matching
SSI	-	Small Scale Irrigation
UNDP	-	United Nations Development Program
USD	-	United States Dollar

Abstract

Poverty is a threat to the world, especially in the developing countries. It is one of the serious problems of human deprivation and a complex phenomenon encompassing inadequate income and assets which are essential elements for human self-worth and survival. This study examines the impact of small-scale irrigation on household multidimensional poverty in Bahir Dar Zuria Woreda; North West Ethiopia using a mixed research approach involving quantitative analysis and some qualitative insights was employed. A data was gathering through a survey of both small scale irrigation participant and non-participant households and the impact of the small scale irrigation practice on the outcome were estimated using Propensity Score Machining technique. Small scale irrigation participation is determined by family size, land size, livestock holding and distance from market sites. The findings reveal that participation in small scale irrigation positively influences household consumption expenditure indicating irrigations impact in household economic gains and improved spending for better livelihood. Likewise, small scale irrigation practice reduces household multidimensional poverty to a significant level. Hence, it is recommended for the local government and interested development agencies to implement targeted programs to encourage and support farmers' participation in small-scale irrigation practices through provision of technical assistance, improving access to irrigable land and affordable irrigation technologies, and training on efficient water management techniques to reduce multidimensional poverty in the study area.

Key Words: Bahir Dar Zuria, Multidimensional Poverty, PSM, Small-Scale Irrigation

CHAPTER ONE: INTRODUCTION

1.1 Background

Development organizations have tried to cognize the nature of poverty and mechanisms of reducing poverty. Although households living in poverty and extreme poverty in developing countries have been decreasing, in sub-Saharan Africa slight progress has made and almost half the population is extremely poor (FAO, 2021). There is a highest regional poverty rate in Sub-Saharan Africa, where (42.7%) of the population is estimated to be below the global poverty line, followed by South Asia (18.8%) and East Asia (7.2%). Nearly, three-fourth of the poor in the developing world lives in rural areas, and rural poverty remains persistent (World Bank, 2015).

Ethiopia has been applying different poverty reduction programs and strategies to fight extreme poverty. The struggle to reduce rural poverty at household level is a continuing challenge (Woldie, et al, 2020). It is a common phenomenon in which a larger proportion of its population lives below 1$ a day (Teshome and Sharma, 2014). The regional distribution of total poverty in Ethiopia in the 2016, poverty incidence is the highest in Tigray with (27%) followed by the Beneshangul-Gumuz (26.5%), and Amhara (26.1%). Larger numbers of poor people are also found in the Amhara region (5.3 million) and the previous SNNP region (3.1 million) in 2015/16. Despite the relative improvement in the past twenty years, the poverty level in Ethiopia is still higher (FDRE, 2018).

Multidimensional poverty in rural Ethiopia is high, with a large gap between rural and urban areas. The multidimensional poverty index is a measure of the proportion of people in poverty and the severity of their deprivations. In response to this wide-reaching problem small scale irrigation development has been regarded as a viable strategy in rural poverty reduction (Hesselberg, 2017). In countries like Ethiopia, where agriculture contributes to 45% of the Gross Domestic Product (GDP), 65% of the total exports and 85% of the employment, small irrigation is expected to have an immense influence of farm income and household poverty reduction (Adugna et al, 2013).

Thus, small-scale irrigation is a policy priority for rural poverty alleviation, growth and climate adaptation. Therefore, in this study the researcher tried to investigate the impacts of small-scale irrigation on household multidimensional poverty in Bahirdar Zuria Woreda, North West Ethiopia to contribute to existing limited literature and fill the gaps in studies.

1.2 Statement of the Problem

Household poverty is a threat to the world, especially to the developing countries. It is one of the most serious problems of human deprivation and a complex phenomenon encompassing inadequate income and assets which are crucial elements for human dignity and survival. Thus, dealing with poverty is a priority development concern in many developing countries including Ethiopia (World Bank, 2015). However, the impact of small irrigation on household poverty is not well studied in Sub Saharan Africa in general and in Ethiopia in particular.

Development scholars debated that the fighting against poverty is a necessary condition for economic growth thereby achieves the wellbeing of citizens. The Sub-Saharan African countries are still suffering from widespread and severe poverty. The Ethiopian economy is founded on the traditional agriculture, the country's national policies and strategies are targeted to reduce poverty through increasing agricultural production (World Bank, 2007).

Although various poverty reduction policies and strategies have been implemented, a significant proportion of the population is still live-in absolute poverty situation (NBE, 2015).

In rural Ethiopia, poverty is a common phenomenon and captures the attention of researchers. Ethiopia is endowed with ample water resources with 12 river basins with an annual runoff volume of 122 Billion M^3 of water and an estimated 2.6 - 2.65 Billion M^3 of groundwater potential. Unluckily, only 5% of irrigable land is irrigated which shows the presence of large potential for changing the livelihood of smallholder farmers (Tucker and Yirgu, 2010; Adugna et al, 2013). On the other hand, Irrigation in Ethiopia is considered as a basic strategy to alleviate poverty. It is useful to transform the rain-fed agriculture which depends on rainfall into the combined rain-fed and irrigation agricultural system. Thus, development of irrigation practices has to be investigated to know its contribution for household poverty reduction (Haile. 2015).

Studies are conducted on the impact of small-scale irrigation on household poverty. However, most of them tried to address household poverty in the form of income poverty, rather than multidimensional poverty. Further, there are inconsistencies to study household poverty, studies such as (Muhdin, 2015) focus on income poverty. Here, income poverty is not enough for interventions by the government and non-governmental organizations.

In this regard some studies (Bruck and Kebede, 2013); Gebrekidan, K., Bizuneh, M., and Cameron, J., 2021), (Sungil Kwak and Stephen C. Smith, 2011) tries to measures poverty by using multidimensional poverty approach. However, there are still gaps which need further investigation and household multidimensional poverty is not studied in the study area for different interventions.

Moreover, there are methodological inconsistencies in the application of data analysis models. Therefore, this study undertaken with an aim to examine the impact of small-scale irrigation on household multidimensional poverty in Bahir Dar Zuria Woreda, North West Ethiopia to fill the gaps and to add to the existing limited works with the application of propensity score matching.

1.3 Objective of the Study

1.3.1 General Objective

The general objective of this study was to investigate the Impact of Small-Scale Irrigation on Household Multidimensional Poverty in Bahir Dar Zuria Woreda, North West Ethiopia.

1.3.2 Specific Objectives

- To assess the status of household multidimensional poverty in the study area.
- To identify the determinants of small scale irrigation participation in the study area.
- To examine impacts of small-scale irrigation on household consumption expenditure in the study area.
- To investigate impacts of small-scale irrigation on household multidimensional poverty in the study area.

1.4 Research Questions

- What is the status of household multidimensional poverty in the study area?
- What are the determinants of small scale irrigation participation in the study area?
- What is the impact of small-scale irrigation on household consumption expenditure in the study area?
- What is the impact of small-scale irrigation on household multidimensional poverty in the study area?

1.5 Significance of the Study

Poverty is a serious problem in most of the developing countries that extensively affecting the community and the rural poor are sorrow from multidimensional poverty. Examining the impacts of small-scale irrigation on household multidimensional-poverty is essential to take poverty reduction measures at household level. The households in Bahir Dar Zuria Woreda have been suffering from education, health and living standard deprivations (BZW, 2020). Examining the impact of small-scale poverty on household multidimensional poverty can enhance the development programs and policies to reduce and eliminate poverty. Thus, this study can play its own role for researchers and development practitioners to utilize the results of this study. Furthermore, the findings of this study could be used by the decision makers and stakeholders in poverty reduction interventions.

1.6 Scope and Limitation of the Study

The study was made to have spatial and thematic delimitation. Spatially, the study was conducted in Bahir Dar Zuria Woreda, North West Ethiopia. The primary focus of this study is on the impact of small-scale irrigation on household multidimensional poverty. Thematically, the study is delimited to examine the level of household multidimensional poverty; to investigate impacts of small-scale irrigation on household consumption expenditure and household multidimensional poverty in Bahir Dar Zuria Woreda, North West Ethiopia. Instead, this study has limitations on the investigation of household poverty by using multidimensional poverty in Bahir Dar Zuria Woreda with cross-sectional data.

1.7. Organization of the Study

This study is organized in five chapters and other sub sections. To see these orderly; the first chapter comprises background of the study, statement of the problem, objective of the study, significance of the study, scope and limitation of the study. Chapter two deals on the literature review part with theoretical and empirical literature review as well as conceptual frame work sub sections. The third chapter of this study which comprises description of the study area, research approach, research design, sampling design, study population, data source with instruments, method of data analysis and model specification. The fourth chapter also presents the result, discussion and interpretations of the study. Finally, chapter five of this study contains the concluding remarks and recommendations of the study.

CHAPTER TWO: LITERATURE REVIEW

In this part the researcher presents theoretical explanations and empirical findings related to household multidimensional poverty with regard to the study objectives and variables. Thus, theoretical literatures on poverty as well as empirical works that explain the participation and impact of small-scale irrigation on household multidimensional poverty by giving emphasis on studies conducted in rural areas.

2.1Definition of Terms

- Household multidimensional poverty: is a non-monetary measure of well-being that considers a range of factors, including health, education, and standard of living.
- Poverty Line: World Bank set international poverty line at periodic intervals as the cost of living for basic food, clothing and shelter changes. Thus, in 2022, the threshold updated to $2.15, which is currently serving as a base for international standard.
- Small Scale Irrigation: The artificial application of water to small plot of land ranging from 0.2 to 0.5 ha, comprising a small number of farmers, using relatively small reservoirs - rivers, dams controlled by the farmers using technology.

2.2Theories of Poverty

The poor are the underprivileged segments of the society who do not have adequate food, shelter and education, health and other basic services (Dawit et al., 2011). Poverty is also a social phenomenon which goes beyond the economic spheres and encompasses inability of individuals to participate in social life and political environment. One way of defining poverty is by letting the poor to explain their own poverty. It is allowing individuals or groups who practically facing poverty to define what represent their basic requirements in life (Ahmed, 2013). The following poverty theories summarize how and in what context poverty exist and arise (Korankye, 2019).

2.2.1 Theory of Individual Deficiencies

The theory set poverty comprised of a large and multifaceted set of explanations that focus on the individual as responsible for their own poverty situation (Addae-Korankye, 2019). Sameti *et al* (2012) states that the individual factors that cause or fuel poverty include individual

attitude, human capital, and welfare participation. Further to the assertion of this theory Bradshaw (2006) blame the poor for creating their own problems arguing that with hard work and better choices the poor could have avoided and solved their problems and also explained poverty as caused by lack of genetic qualities such as intelligence that are not so easily reversed.

This theory of poverty is criticised on the grounds that with the emergence of the concept of inherited intelligence in the 19th century, the eugenics movement went on to rationalise poverty and even sterilised those who appear to have limited abilities (Bradshaw, 2006). Moreover, there is an emerging believe that the poor are afflicted by the mark of Cain; they are meant to suffer, indeed must suffer because of their moral failings.

2.2.2 Theory of Cultural Beliefs

This theory roots its cause in the "Culture of Poverty". The theory demonstrates that poverty is created by the transmission over generations of a set of beliefs, values, and skills that are socially generated but individually held. Hence, individuals are not necessarily to blame because they are victims of their dysfunctional subculture or culture (Bradshaw, 2006). Sometimes this theory is linked with the individual theory of poverty or other theories. In a general sense, the culture of poverty and social exclusion gives us frameworks to explain how poverty is created and maintained in some neighbourhoods or among some groups.

Lewis (1966), one of the main witters to define the culture of poverty, assumes that both the poor and the rich have different pattern of values, beliefs, and behavioural norms. He indicated culture of poverty as a set of beliefs and values passed from generation to generation. Therefore, the theory asserts that the poor are poor because they learn certain psychological behaviours associated with poverty (Addae-Korankye, 2019). Overall, the theory is criticised by holding the poor responsible for their situation rather than social forces associated with poverty.

2.2.3 Theory of Economic, Political and Social Distortions

The theory is mostly linked to the structure of the larger socio-economic order. Believers of this theory links the source of poverty to economic, political, and social system which cause people to have limited opportunities and resources with which to achieve income and well-being. The theory look not to the individual as a source of poverty, but to the wider

economic, political, and social system which causes people to have limited opportunities and resources to define their status of poverty. The theory further asserts that within a market-based competitive economic system, unequal initial endowments of talents, skills and capital which determine productivity of individual cause poverty (Samati *et al*, 2012; Addae-Korankye, 2019).

Further to the theory Rank (2004) indicated that certain demographic appearances such as race, gender, work disability, family size and structure, residence and age are factors that increase or decrease the risk of poverty and demonstrated that poverty rates are higher among single parent household, women, minority groups, households with large number of children, and families.

2.2.4 Theory of Geographical Disparities

The theory views poverty from a geographical perspective which is observed to have disparities from place to place and such attempt to theorise the geographical perspective of poverty led to the emergence of geography of poverty (Abdulai and Shamshiry, 2014; Addae-Korankye, 2019). Bradshaw (2006) clearly indicated that rural poverty, ghetto poverty, urban disinvestment, Southern poverty, third-world poverty, and other framings of the problem demonstrates a spatial characterization of poverty that exists separate from other theories. The theories related geography build on the other theories and shows that people, institutions, and cultures in certain areas lack the objective resources needed to generate well-being and income.

Agglomeration is mostly used to explain the emergence of strong industrial clusters, the central place theory is related to the flows of knowledge and capital to specific centre while selective outmigration theory is related to the concept that people from disadvantaged areas with the highest levels of education, the greatest skills, widest world view and extensive opportunities were the ones who migrated out of the areas where poverty prevail which could aggravate the poverty situation the origin and contribute in its eradication in the destination (Omideyi, 2008).

2.2.5 Theory of Cumulative and Cyclical Dependencies

This theory is considered to be the most complex and to some degree builds on components of each of the other theories. The theory looks individual and their community as caught in a spiral of opportunity and problems, and that once problems dominate they close other opportunities and create a cumulative set of problems that make any effective response nearly impossible and leading them to be observed in poverty situation (Bradshaw, 2006).

The cyclical explanation explicitly looks at individual situations and community resources as mutually dependent. For instance, in uncertain economic situation creating individuals who lack resources to participate in the economy makes economic survival even harder for the community since people pay fewer taxes which could be used for poverty reduction efforts. Overall, this theory is called the cyclical theory of poverty where the poverty situation occurs when individuals or households are suddenly unable to provide for their necessities due to unforeseen circumstances (Abdulai and Shamshiry, 2014; Addae-Korankye, 2019).

2.3 Measurement of Poverty

The measurement of poverty dynamics has been long of interest for development economists and policy makers. The poor is not similar and homogeneous group at all. It include the chronically poor who are very poor for a long period and the transiently poor who experience both poverty and non-poverty years during that period of time (Hulme and Shepherd, 2003).

Measuring poverty take time, energy and money as it can only be done properly by gathering survey data directly from households and or individuals. Poverty is conceptualized and measured in different ways where the various ways poverty is conceptualized and measured are very crucial because different poverty measures tend to capture different people as poor (Sameti, Esfahani and Haghighi, 2012). For instance, historically, poverty has been calculated based on a person's income and the multidimensional measures (World Vision, 2021).

Measuring poverty is important for a number of reasons. One is that poverty measures provide estimates of the magnitude of the problem and raise its visibility to keep the poor people on the policy agenda. On the other, poverty measures are needed to identify poor people and pockets of poverty and devise related targets and appropriate policy interventions (UNECE, 2017).

There are two ways of thinking on poverty measurement, absolute and relative poverty measurements. In absolute poverty, a set of standards which are considered to be consistent over time and countries are used. Some of could be misbuttoned as Human Development Index and those that use a poverty line like food, non-food and national poverty line measures. On the other, relative measurements views poverty as a socially defined and dependent on social context which make it a measure of inequality which could be include those like Lorenz Curve, Gini coefficient (INE, 2014; UNECE, 2017). Overall, the most common and widely used measures of poverty are discussed in brief below

Headcount index (P_0) measures the proportion of population that is poor. The head count poverty measure is popular because it is easy to understand and measure. The most common draw back of the measure is that it does not show how poor the poor are.

Poverty gap index (P_1) measures the extent to which the individuals fall below the poverty line or the poverty gaps as a proportion of poverty line. The sum of these poverty gaps gives the minimum cost of eliminating poverty, if transfers were perfectly targeted. Its drawback is related to the fact that the measure does not reflect changes in inequality among the poor.

Squared poverty gap or **poverty severity index** (P_2) is derived by averaging the squares of the poverty gaps relative to the poverty line. It is one of the Foster-Greer-Thorbecke (FGT) classes of poverty measures.

2.4Empirical Literature Review

Small-scale irrigation developments were targeted to positively benefit and contribute for the intensification and supporting of crop-livestock mixed farming systems since the practice improves climate resilience in the rainy season through supplementary irrigation and provides off-season benefits as it enables agricultural production in the dry season. The intensification of production in turn contributes positively impact household income, nutrition and ultimately livelihoods (Dereje et al, 2009; Schmitter et al, 2016).

Irrigating farmers are more resilient to extreme weather events across seasons. This is mainly because, smallholder farmers can irrigate high-value cash crops as well as more nutrient dense horticultural crops though some crop-technology combinations which could enable them to show higher profitability than others. For instance, irrigators in Ethiopia achieve

double the agricultural income per hectare during the dry season compared to non-irrigator small holder farmers (Feed the Future, 2021).

Tolla (2021) in his study found that age, education, family size, livestock ownership, and extension service significantly impacted household adoption of small-scale irrigation. The Propensity Score Matching model results showed that participation in small-scale irrigation interventions had a significant, optimistic and robust influence on income and consumption variables. The projected participation effect's sensitivity to unobserved selection bias was also tested using the Rosenbaum bounds method.

Tesyaye et al (2011) conducted a study in the Ambo district of western Ethiopia in 2006 to understand the poverty reduction impacts of small-scale irrigation development. The sample size for the study was 222 (107 households with access to irrigation and 115 without). The result indicates that the incidence, depth, and severity of poverty are significantly lower among those farm households with access to irrigation. In addition to irrigation, other variables such as farm size, livestock holding size, land productivity, and family size significantly influence the level of household consumption expenditure. However, the proportion of poor people in the overall sample, notwithstanding access to irrigation, is alarmingly high, indicating the deep-rooted and critical situation of poverty in rural Ethiopia.

Tesgera and Guluma (2020) in their study believed that irrigation practices are a good strategy in improving the standard of living of users in comparison to non-users. Irrigation users have higher living standard than that of non-use. Concerning the development of small scale irrigation, Ethiopia has high potential of irrigable land and water resources. However, the exploitation of an irrigable land is only about 5 to 6%. This means, irrigation as a good strategy of improving standard of house hold living is not given attention by the public authority. As a result, its contribution to the national economy is not significant when compared to rain-fed agriculture.

Hirko T., Ketema M., and Beyene F, (2018) in their study on impact of participation on small-scale irrigation on household income in Abay Chomen district. The result revealed that participation in small-scale irrigation had a significant effect on household income. Since participation in small-scale irrigation have significant effect in improving household income, the government, should attempt to hamper factors that hinder participation in small-scale

irrigation and enhance factors that initiate participation to improve participation in small-scale irrigation and hence household income in the study area.

Legesse et al (2018) in their study using the Propensity Score Matching analysis indicate that participation in irrigation use has increased annual household farm income by the 19,474.8 ETB for participant households than the non-participant households which are significant at 1% level. Similarly, it has increased their physical asset holding which is measured in Ethiopian birr valued 27,502 ETB at 1% statistically significance level.

Kassie, Alemu and Wodajo (2018) in their study found that poverty intensity and multidimensional poverty index of the study area were lower than the national and regional averages. Nonetheless, the trend of poverty reduction was not evenly progressed in irrigator and non-irrigator households. The proportion of non-irrigator poor and MPI poor households were greater than irrigators. The endogenous switching model and key informant interviews proved that irrigation has positive impact on multidimensional household poverty reduction. However, the incidence of poverty among the sample households, regardless of access to irrigation, is still higher. This implies access to irrigation should be accompanied by institutional supports and complementary production inputs.

Ayele, K. (2013) in his study to examine impact of small-scale irrigation in the Lake Tana basin of Ethiopia on household income and likelihood of poverty found that households using any of the irrigation systems had statistically significantly higher mean total gross household income than households not using irrigation. The marginal impact of small-scale irrigation on the gross household income indicated that each small scale-irrigation user increased mean annual household income by ETB 3353/year, 27% increase over income for non-irrigating households. The findings indicated that access to irrigation significantly reduced the odds that a household would be in the lowest quartile of household income, the poverty threshold in his study.

2.5 Literature Gaps

Ethiopia is richly endowed with water resources, comprising 12 river basins with an annual runoff of 122 billion cubic meters and an estimated groundwater potential of 2.6 to 2.65 billion cubic meters. However, only 5% of the country's irrigable land is currently under irrigation, indicating significant untapped potential to enhance the livelihoods of smallholder farmers (Tucker and Yirgu, 2010; Adugna et al., 2013). Irrigation is regarded as a key strategy for poverty reduction in Ethiopia, as it offers an opportunity to shift from reliance on rain-fed agriculture to a system that combines rain-fed and irrigated farming. Therefore, it is essential to explore the development of irrigation practices to assess their impact on reducing household poverty (Haile, 2015).

The above literature review reveal that, studies have examined the impact of small-scale irrigation on household multidimensional poverty. However, the majority have primarily focused on income poverty rather than adopting a multidimensional perspective. Such as, studies such as Muhdin (2015) emphasize income poverty, which may not provide sufficient insights for effective interventions by government and non-governmental organizations. While some research (Bruck and Kebede, 2013; Gebrekidan et al., 2021; Sungil Kwak and Stephen C. Smith, 2011) has utilized a multidimensional poverty approach, significant gaps remain, particularly in understanding household multidimensional poverty in the study area, which is crucial for targeted interventions. Furthermore, methodological inconsistencies in the application of data analysis models further highlight the need for more robust and comprehensive investigations.

2.6Conceptual Framework

Based on the theories and empirical literature conferred, the conceptual framework tries to align with the study objective, household irrigation participation and its impact on household multidimensional poverty. Thus, the conceptual framework of this study showed here in figure.

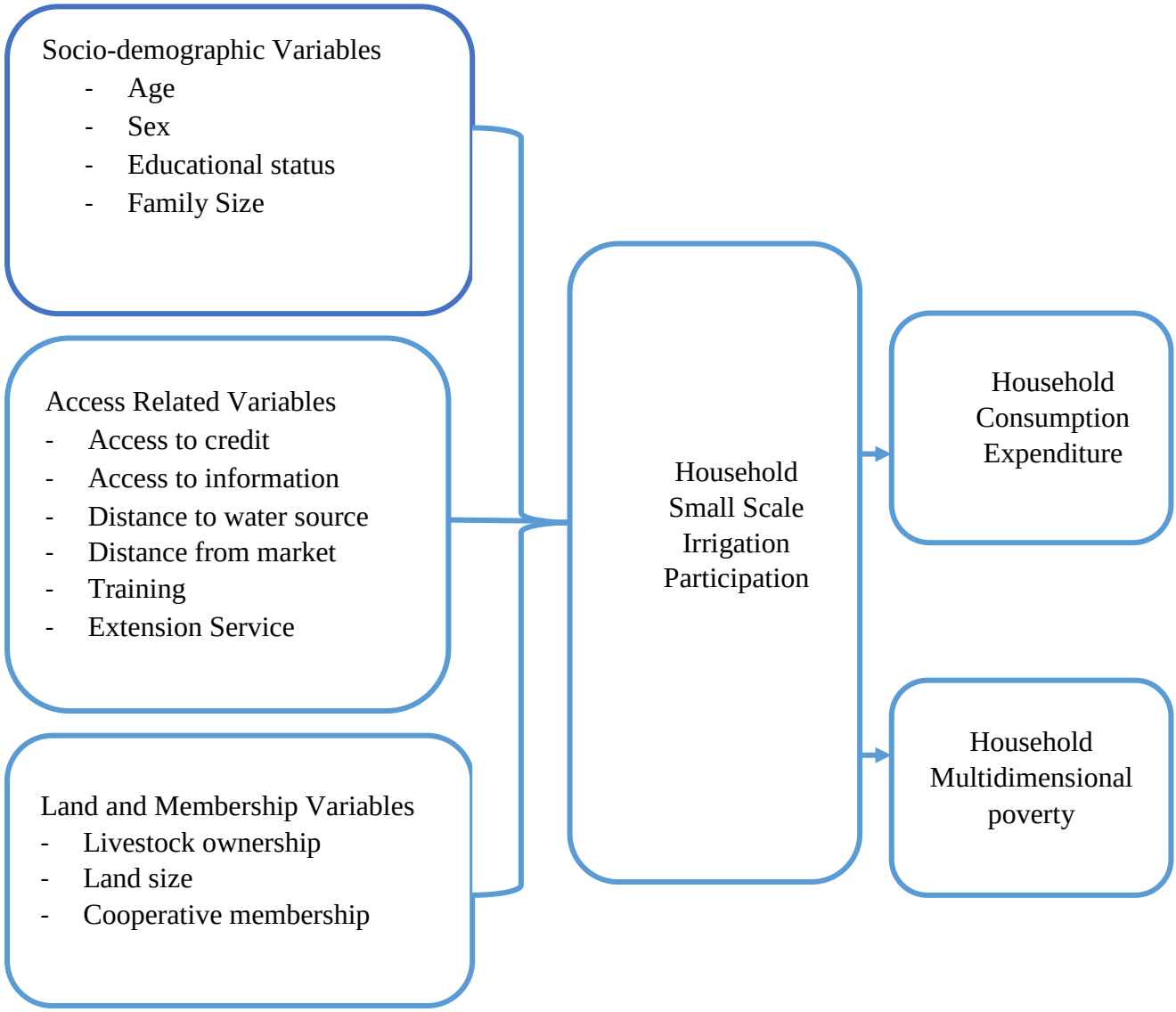


Figure 1: Conceptual framework developed by the researcher, 2024

CHAPTER THREE: RESEARCH METHODOLOGY

This chapter elaborates description of the study area and the methodology that the researcher used to achieve the study objectives and to provide answer to research questions. Here, the research design as a broad blue print includes the sampling techniques, the data type, source and instruments used for data collection and methods of data analysis as well as model specification are presented in detail.

3.1 Description of the Study Area

This study is conducted in Bahir Dar Zuria Woreda administrative which is located in North Gojjam Zone, Amhara Regional State, Ethiopia. The district has 36 rural kebeles and it is very close to Bahir Dar City, which is the capital city of Amhara National Regional State.

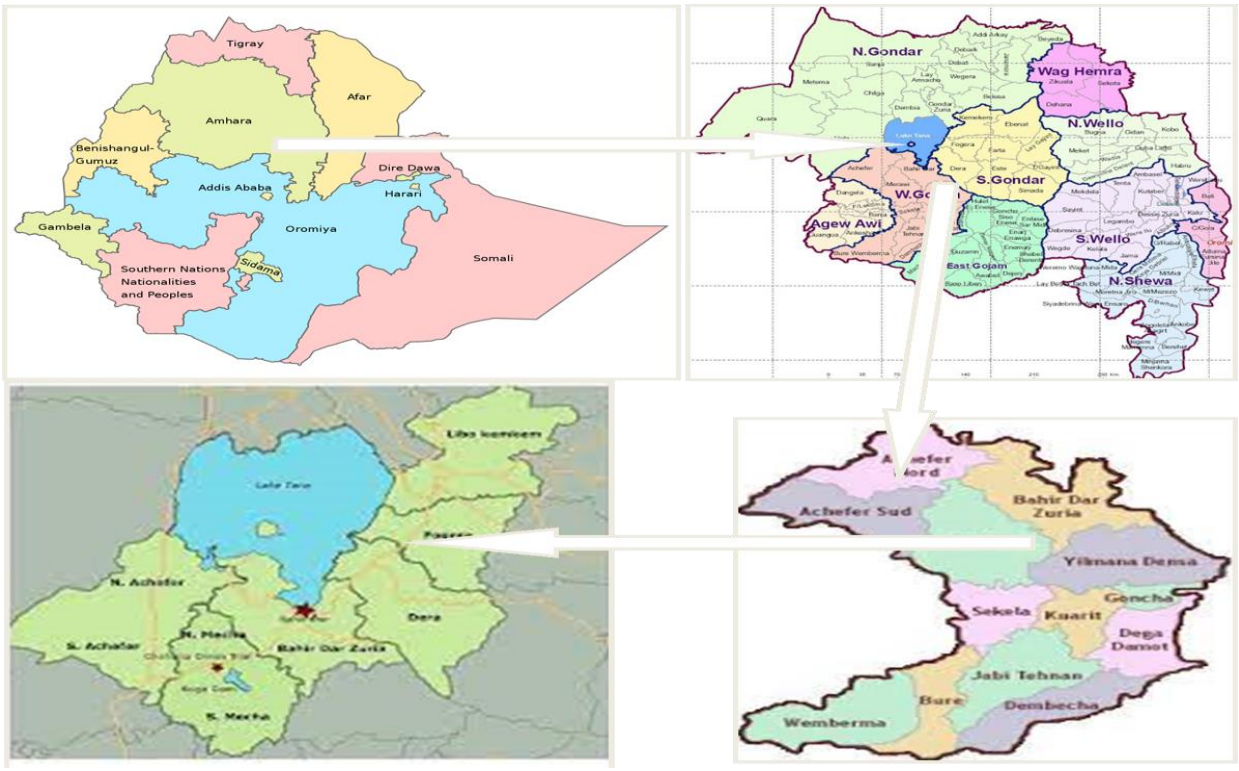


Figure 2: Map of the Study Area

According to the Central Statistical Agency of Ethiopia (2007), this district has a total population of 182,730, of whom 93,642 are men and 89,088 women; no urban inhabitants were reported. With an area of 1,443.37 km^2, Bahir Dar Zuria Woreda has a population density of 126.60, which is less than the Zone average of 158.25 persons per square kilometer.

A total of 40,893 households are counted in this woreda, resulting in an average of 4 persons to household and 40,097 housing units. Agriculture dominantly relies upon rainfall and traditional method of farming. The woreda has irrigation potentials kebeles like Yigoma Huletu, sebatamit, gula-gulma, wonjeta wogelfa and Robit kebeles are mostly practicing small-scale irrigation. The farmers make their livelihood by producing food crops and cash crops, such as fruits and vegetables using small scale irrigations. On average farmer's land size is 1.5 hectare, Bahir Dar zuria wereda has mainly weina dega agro-climatic conditions, with altitudes ranging from 1,345 to 2,355 meter above sea level, and 70% of the territory with plain features (MoA, 2019).

3.2 Research Approach

This study employed a mixed research (quantitative and qualitative) approach to describe and critically examine the existing phenomenon and to examine the impact of small-scale irrigation on household multidimensional poverty in the study area. Creswell and Plano (2011), a mixed-methods research design is a research design that has its own philosophical assumptions and methods of inquiry. Mixing the two might be superior to a single method as it is likely to provide rich insights into the research phenomena that cannot be fully understood by using only qualitative or quantitative methods.

3.3 Research Design

This study used a descriptive cross-sectional research design to achieve the study objectives. Descriptive research is a research method that describes the characteristics of the population or the phenomenon. The study also used the respondents' or household heads as a unit of analysis. Therefore, a cross sectional research method was used to examine the impact of small-scale irrigation on household multidimensional poverty in Bahir Dar Zuria Woreda, North West Ethiopia.

3.4Data Type, Source and Methods of Data Collection

Primary and secondary data were used by employing the data collection instruments to achieve the study objectives. Primary data was collected from the sampled household heads and from the key informants in the study area. This study also used data structured interview questionnaires and the key informant interview guideline as data collection instrument.

The structured questionnaires are prepared and translated to “Amharic” which is the working local language in the study area. This technique was used to collect cross sectional data from primary sources which are administered by university degree graduates in the study area. The interviewers were oriented by the researcher and become familiar on the interview process, purpose of the study and how to approach ethically to generate reliable data. Further, key informant interview was held with experts, team leaders and heads. Secondary sources of data were also be considered and used as a source to gather data from the published and unpublished resources. The manuals, journal articles, the sector reports, previous studies and regulations in relation with this study were also reviewed.

3.5 Sampling Design

3.5.1 Study Population and Sampling Frame

The study area, Bahir Dar Zuria Woreda is selected purposively among districts in North Gojjam Zone, because the researcher knows the area well and there are a number of small-scale irrigation potential kebeles in the Woreda. According to (BZW, 2020) the Woreda has 36 administrative kebeles which has 40,893 households. Household heads are the smallest sampling units in this study and the heads of each household served as a target study population.

The district is mostly characterized by “Woina-Dega” agro-ecology zone and plain with no significant agro-ecology difference among rural kebeles and has nearly similar socio-economic and culture among households. However, households in the kebeles are stratified based on their irrigation participation and non-participation. Therefore, considering the time and resource limitation two kebeles with 2,272 household heads form the sample frame for this study.

3.5.2 Sample Size and Sampling Techniques

Both probability and non-probability sampling techniques were used to determine the survey households. The sample size in this study was determined based on Yamane (1967) simplified formula to calculate sample sizes assuming a 95% confidence interval and p = 0.05 level as shown below.

$$n = \frac{\mathrm{N}}{1+\mathrm{N(e)2}} \qquad \mathrm{n} = \frac{2{,}272}{1+2{,}272\ (0.05)2} = 340$$

Where ´n´ is the sample size, ´N´ indicates the size of population, and ´e´ is the level of accuracy. Since, the target population is less than 10,000 the desired sample size is adjusted using the finite population correction formula. Because a given sample size provides proportionately more information for a small population. Based on this, the sample size is adjusted as:

$$fn = \frac{n}{1+\frac{n-1}{N}} \qquad fn = \frac{340}{1+\frac{340-1}{2,272}} = 296$$

Where: N= target population size (2,272)
fn = adjusted sample size
n = sample size (340).

Thus, the sample size based on the commutation above is made to be 296. Therefore, 296 sample household heads from irrigated and non-irrigated kebeles were selected proportionally. Further, key informants experts and officials have been selected from finance, plan and development and irrigation and lowlands offices at district, zone and regional level.

3.6 Method of Data Analysis

The data was analyzed by employing both the qualitative and quantitative methods of data analysis. Qualitative data collected from key informants have been systematically analyzed by through qualitative data analysis technique to justify and elaborate the quantitative data.

Further, the statistical data analysis takes the form of descriptive statistics, which was presented as frequency, percentage, table, mean and standard deviation to describe the characteristics of respondents. Poverty line or cut off has been estimated by using cost of basic needs approach in this study. The inferential statistics was also used to examine the impact of small-scale irrigation on household multidimensional poverty in the study area. Propensity Score Matching was employed to estimate the impact of small-scale irrigation on household multidimensional poverty. Finally, the data was entered, cleaned it and analyzed through STATA software.

3.7The Model Specification

3.7.1 Binary Logistic Regression

Household participation in small scale irrigation which was measured as a binary outcome, best measured in terms of small scale irrigation participation by the households. In this study to investigate the determinants of irrigation participation, binary logistic regression was used. This model is a statistical technique for predicting probability of an event, given a set of predictor variables.

Logistic regression was used to predict the propensity of participation of small scale irrigation on the basis of independent variables and to determine the effect size of the independent variables on the dependent variable and to understand the degree of effect of predictor variables. The impact of predictor variables is usually explained in terms of odds ratio and hence the name logistic regression, also called the log-odds function. This model applies maximum likelihood estimation after transforming the dependent variable into a logit variable (the natural log of the odds of the dependent variable occurs or does not occur). Binary logistic regression is one part of logistic regression which is predictive model that can be used when the outcome variable is categorical variable with two choices and the independent variables are of any type.

3.7.2 Propensity Score Matching

Propensity score matching (PSM) constructs a statistical comparison group that is based on a model of probability of participating in the treatment, using observed characteristics. Participants are then matched on the basis of this probability to nonparticipants. The average treatment effect of the program is then calculated as the mean difference in outcomes across two groups. On its own, PSM is a useful approach when only observed characteristics are believed to affect irrigation participation. Whether this belief is actually the case depends on the unique features of the program itself, in terms of targeting as well as individual take up of small-scale irrigation. Assuming selection on observed character is strong to determine irrigation participation. Tests can be conducted to assess the degree of selection bias on unobserved characteristics.

PSM involves constructing a counterfactual comparison group in order to address the evaluation problem. It uses probit model to generate the propensity score. It then matches beneficiary and control units that have similar propensity scores. Specifically, PSM estimates the average impact of small-scale irrigation participation on participants by constructing a statistical comparison group on the basis of the probability of participating in the treatment D conditional on observed characteristics X, given by the propensity score (Rosenbaum and Rubin, 1983).

$$P(\chi i) = Pr(Di = 1 \perp X) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where: Y1i = the outcome of unit i if i were exposed to the treatment Y0i =the outcome of unit i if i were not exposed to the treatment Di ∈ {0, 1} = indicator of the treatment actually received by unit iYi = Y0i + Di (Y1i – Y0i) = the actually observed outcome of unit i and X-multidimensional vector of pre-determined characteristics (Rosenbaum and Rubin, 1985). As a result, given a population of units symbolized by i, if the propensity score P (Xi) is known as average effect of Treatment on the Treated (ATT) can be estimated as:

$$T = E\{Yi^1 - Yi^0 \,\big|\, Di = 1\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$
$$= E\{E\{Yi^1 - Yi^0 \,\big|\, Di = 1, p\,(Xi)\}$$
$$= E\{E\{Yi^1 | Di = 1, p\,(Xi)\} - E\{Yi^0 | Di = 0, p\,(Xi)\} \,|Di = 1\}$$

Where the outer expectation is over the distribution of (p (Xi) |Di = 1) and Y1i and Y0i are the potential outcomes in two counterfactual situations of (respectively) treatment and no treatment. Following Rosenbaum and Rubin (1983), the approach operates with the following assumptions: First, conditional independence assumption: given a set of observable covariates *X* which are not affected by treatment, potential outcomes are independent of treatment assignment: un-confoundedness, is that after controlling for *X*, mean outcomes of non-treated is identical to outcomes of the treated if they had not received the program.

$$\mathrm{Yi}^1, \mathrm{Yi}^0 \perp T\mathrm{i}, \mathrm{Xi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

This implies that selection is solely based on observable characteristics and all variables that influence treatment and outcomes simultaneously are observed by the researcher. If the balancing hypothesis of un-confoundedness is satisfied, observations with the same propensity score must have the same distribution of observable and unobservable characteristics independently of treatment status.

Thus, treatment effects can be estimated by:

$$\beta = E\left(Yi^1 \mid Xi, Ti = 1\right) - E\left(Yi^0 \mid Xi, Ti = 0\right)$$
$$= E\left(Yi^1 - Yi^0 \mid Xi, Ti = 1\right) + E\left(Yi^0 \mid Xi, Ti = 1\right) - E\left(Yi^0 \mid Xi, Ti = 0\right)$$
$$= Yi^1 - Yi^0 \mid Xi, Ti = 1)$$
$$= E\left(Yi^1 - Yi^0 \mid Xi\right) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (4)$$

Thus, because of conditional independence the selection effect=0, since

$$E\left(Yi^0 \mid Xi, Ti\right) = E(Yi^0 \mid Xi)$$

$$ATE = ATET \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (5)$$

The second assumption is ‘common support’ a further requirement besides independence is the common support. It rules out the phenomenon of perfect predictability of *D* given *X*:

(Over lap) $0 < P(D = 1 \mid X) < 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (6)

This ensures person with the same *X* values have a positive probability of being both participant and non-participant (Heckman, LaLonde, and Smith, 1999). Treatment units therefore have to be similar to non-treatment units in terms of observed characteristics not affected by participation; thus, units that fall outside the region of common access would be dropped.

Estimation Strategy: Given CIA holds and assuming there is overlap between both groups (strong ignorability), the PSM estimator for ATT can be written as:

$$ATT = E\ p(x)|D = 1\{E[Y(1)|D = 1, P(X)] - \{E[Y(0)|D = 0, P(X)]\} \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

The propensity score matching estimator is the mean difference in outcomes over the common support, properly weighted by the propensity score distribution of participants.

Table 3-1: Definition of Variables

Variable	Definition of Variable	Measurement
Outcome Variable		
Household poverty	Household multidimensional poverty	Binary
Dependent Variable/Treatment variable		
Irrigation participation	1, if a household head used irrigation, 0 if not	Binary
Independent Variables/covariates		
Age	Age of household heads in year	Continuous
Sex	Sex of household head, 0 = male 1 = female	Binary
Education level	Level of education of the household head	Categorical
Family_size	Household size	Continuous
Access to credit	Credit access from formal financial institution	Dummy
Land size	Household heads land holding size in hectare	Continuous
Access to information	Access to basic information (radio/TV)	Dummy
Training	Households access to irrigation trainings	Dummy
Livestock ownership	Having livestock	Dummy
Extension service	Access to agricultural extension service	Dummy

Source: Literatures Reviewed, 2023

3.8Reliability and the Validity of Instruments

Reliability of the structured questionnaire used in this study has been guaranteed through serious and successive evaluation of this tool for data collection by academicians where relevant changes and additions were made where necessary. Alternatively, to convince validity, questionnaires were designed on the basis of previous studies' questionnaires and related literature and the objective realities of the area under study.

Further, to make the tools more appropriate to the study area, questionnaire has been given to independent experts to evaluate it for content validity as well as for conceptual clarity and investigative bias. Furthermore, pilot test has been undertaken by distributing about 10 households to refine the methodology before administering the final data collection.

Questionnaires have been tested on potential respondents to make the data collecting instruments objective, relevant, suitable to the problem and reliable.

3.9 Ethical Consideration

This study keeps the data collection efforts in line with ethically acceptable guideline. To insure this, the study gets consent from the concerned district administrative office. Further, all the study participants included was duly informed about the purpose of the study and their willingness and agreement have been secured earlier filling the structured questionnaires. This study also maintains the privacy of each study participant.

CHAPTER FOUR: RESULTS AND DISCUSSION

In this section the result, discussions and analysis of the primary data collected through questionnaires are included. Overall, the first part deals with demographic and socio-economic background characteristics of respondents. The second section is about the rate of participation in small-scale irrigation, irrigation practices, and farm households' access to different services and facilities. The last two parts deal with the impact of small-scale irrigation on household consumption expenditure and household multidimensional poverty status.

4.1Results of Descriptive Statistics

4.1.1. Demographic and Socio-Economic Characteristics of Respondents

The session provides evidence on the socioeconomic and demographic characteristics of the respondents. The data presented in Table 4.1 provides information on the sex of household heads in line with their participation in small-scale irrigation activities. Of the 292 household heads, (20.89%) are female and (79.11%) are male in small-scale irrigation. Further, the result show that more males participate in small-scale irrigation activities than females. However, the chi-squared test statistics indicated that there is no significant association between the sex of the household head and participation in small-scale irrigation activities, the resulting p-value is 0.858, which is greater than the 0,05 level of significance.

Table 4-1: Sex and Educational status of respondents by participation in small-scale irrigation

Sex	Small Scale Irrigation						X^2 test
	Non-Participants		Participants		Total		
	Frq.	%	Frq.	%	Frq.	%	
Female	28	20.44	33	21.29	61	20.89	chi2(1) = 0.0320 Pr = 0.858
Male	109	79.56	122	78.71	231	79.11	
Total	137	100	155	100	292	100	
Educational Status							
Illiterate	75	54.74	75	48.39	150	51.37	chi2(2) =1.5059 Pr = 0.471
Read and write	43	31.39	59	38.06	102	34.93	
Formal Education	19	13.87	21	13.55	40	13.7	
Total	137	100	155	100	292	100	

Source: Field survey, 2023

Table 4.1 on the educational status of respondents indicated that, from the overall respondents of the study 51.37% are illiterate, 34.93% can read and write, and 13.70% have formal education. The descriptive assessment reveals that participation rates in small-scale irrigation vary across educational status, with illiterates having a 50% participation rate, those

who can read and write at 57.84% and individuals with formal education at 52.5%. However, the chi-squared test results indicate that there is no significant association between educational status and participation in small-scale irrigation, as p-value of 0.471 is not significant at 5% level. Moreover, assessment of the year of schooling for those with a formal education indicates that non-participants have a mean year of schooling of 9.78 (SD= 3.39) years while participants of small-scale irrigation have a mean value of 7.73 (SD=4.17) which entails the absence of considerable difference.

Table 4.2 provides information on the age and family size of respondents by their participation in small-scale irrigation. The mean age for non-participants is 38.4 with a standard deviation of 10.4 years, while for the irrigation participant households; the mean age is 38.2 with a higher standard deviation of 11.8 to indicate the presence of considerable difference within-group variability in age. Moreover, the t-test comparing the ages of participants and non-participants results in a t-value of 0.106, indicating no significant difference in age between the two groups.

Table 4-2: Age and Family size of respondents by participation in small-scale irrigation

Irrigation Practice	Age			t-test
	Obs.	Mean	Std. Dev.	
Non-Participants	137	38.4	10.441	
Participants	155	38.2	11.793	t = 0.106
Total	292	38.3	11.160	
		Family Size		t-test
Non-Participants	137	4.9	1.427	
Participants	155	5.0	1.148	t = -0.694
Total	292	4.9	1.285	

Source: Field survey, 2023

Concerning family size, the mean family size for non-participants is 4.9 with standard deviation of 1.4, and for participants of irrigation practice, the mean family size is slightly higher with a mean value of 5.0 with a lower standard deviation of 1.2. It implies the result is more or less in line with the national average family size of 4.6. The t-test result with a t-value of -0.694 further clarifies that there is no significant mean difference in family sizes between participants and non-participants.

Table 4.3 on land size and production frequency per year categorized by participation in small-scale irrigation. Looking to land size which is made to be inclusive of land reserved to grazing, the mean land size for non-participants is about 1.30 hectares with a standard deviation of 0.75, while for participants it is observed to be slightly larger with a mean value

of 1.41 hectares with a lower standard deviation of 0.62 where the slight difference is mostly attributed to the presence of some additional land in irrigated fields. The t-test result comparing land sizes between participants and non-participant with a test statistic of -1.344 indicates the slight difference in land size is not statistically significant at 5% level.

Table 4-3: Land size and production frequency per year by participation in small-scale irrigation

Irrigation Practice	Land size			t-test
	Obs.	Mean	Std. Dev.	
Non-Participants	137	1.30	0.750	
Participants	155	1.41	0.621	t = -1.344
Total	292	1.36	0.685	
	Production time per year			t-test
Non-Participants	137	1.04	0.205	
Participants	155	2.37	0.485	t = -29.799
Total	292	1.75	0.766	

Source: Field survey, 2023

On the other hand, looking to production frequency per year, non-participants have a mean production time of 1.04 with a standard deviation of 0.205 per year, while irrigation practice participants have a significantly higher mean production time of 2.37 with a standard deviation of 0.485 per year. The t-test comparing production frequencies between the two groups results in a t-value of -29.8, indicating a significant mean difference in production frequency per year between the irrigation participants and not participants with participants showing a much higher production frequency compared to non-participants in small-scale irrigation since access to irrigation improve the number of productions by farm households.

Table 4.4 shows the distribution of livestock holding among participants and non-participants in small-scale irrigation. Among non-participants, 23.4% of the households do not have livestock, while 76.6% do have livestock. Whereas, among the participants of small scale irrigation, 23.2% of the households do not have livestock, and 76.8% do. Overall, with almost a similar pattern 23.29% of the households do not own livestock while about 76.71% have some livestock.

Table 4-4: Livestock holding among small-scale irrigation practice participants and non-participants

Livestock Holding	Small Scale Irrigation						X^2 test
	Non-Participants		Participants		Total		
	Frq.	%	Frq.	%	Frq.	%	
No	32	23.4	36	23.23	68	23.29	chi2(1) = 0.0007 Pr = 0.979
Yes	105	76.6	119	76.77	224	76.71	
Total	137	100.0	155	100	292	100	

Source: Field survey, 2023

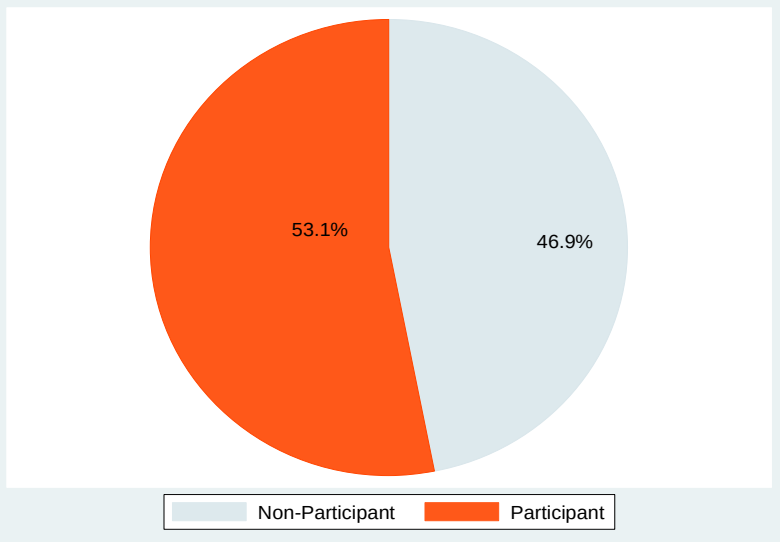
The resulting chi-square test statistic value of chi2 (1) = 0.0007 and corresponding to a p-value of 0.98 indicates that there is no significant association between small-scale irrigation participation and livestock holding among smallholder farmers in the study area. This implies that the data does not provide evidence to suggest that holding livestock differs significantly between participants and non-participants in small-scale irrigation practices.

4.1.2. Participation in Small-Scale Irrigation and Irrigation Practices

Based on the information provided in Figure 3, the result indicates that among the sampled respondents, approximately 53.1% participated in small-scale irrigation practices, while non-participant households accounted for about 46.9% of the study participants. The households' access to such infrastructures could be attributed to better opportunities for farm households to increase household production, improved food security, and enhance living standards.

Further, the qualitative results of the study highlighted several factors that influence households' access and participation in irrigation practices. These factors include the proximity to small-scale irrigation infrastructures, the availability of irrigable land allocated for young people with no access to farmland, and the level of contribution made by households during small-scale dam construction for irrigation purposes.

Figure 3: Participation in small-scale irrigation practice among respondents



Source: Primary data collected, 2023

The data from Table 4.5 shows the top three prominent irrigated crops cultivated by participants of small-scale irrigation. It was found that potato was the most commonly irrigated crop, with 58.06% of participants, followed by tomato with 42.58% and maize with 38.06%. Interestingly, the area is well known for the higher production performance of maize in the regional state and maize still ranked as one of the top three irrigated crops overall. The data suggests that potatoes, tomatoes, and maize are the preferred crops among participants of small-scale irrigation practices followed by the newly introduced wheat production through irrigation at the fourth place.

Table 4-5: the top three prominent irrigated crops by participants of small-scale irrigation practice

	No		Yes	
Irrigated Crop	Frq.	%	Frq.	%
Potato	65	41.94	90	58.06
Tomato	89	57.42	66	42.58
Maize	96	61.94	59	38.06

Source: Field survey, 2023

Further, looking the result on average land size covered by top three crop products, average land size covered by maize is about 0.38 hectares with a standard deviation of 0.49, and which is higher than the national average of 2022, which is 0.23 hectare. While potato is the second with an average of 0.39 hectares which is higher than the national average 0.10 hectares and it is observed to be notably lower for tomato with an average of 0.18 hectares

which is also higher than the national average of 0.03 hectares in 2022. Overall, the result indicates that the average land size covered by the top three crop products is relatively higher than the national average, which may be because of the area is reach in water sources and its proximity to Bahir dar city and other surrounding towns creates market opportunity to small scale irrigation products.

The qualitative findings also suggest a lack of proactive measures to enhance the land allocated for irrigation among smallholder farmers beyond the administration and maintenance of existing small-scale irrigation infrastructure. The extension services seem to fall short in systematically targeting small-scale irrigation and adapting to the specific conditions prevalent in the areas surrounding. This indicates a potential gap in support for improving irrigation practices and optimizing land usage among smallholder farmers in the study area. Addressing these challenges and tailoring extension services to local context could potentially enhance productivity and sustainability in the area.

4.1.3. Households Access to Services and Facilities

Table 4.6 provides a comprehensive overview of the household access to services and facilities with a comparative data among participants and non-participants. The result indicated that access to credit from formal institutions is almost evenly distributed among participants and non-participants, with 54.2% of participants and 48.9% of non-participants having access to credit from formal financial institutions. This suggests a relatively equitable distribution of credit access among households, regardless of their participation status in irrigation practice which is mostly accessed from microfinance institutions.

In terms of media availability for better information, a significant majority of non-participants (82.5%) and irrigation practice participants (85.8%) have access to radio/television. This indicates the presence of relatively greater access to information and communication resources, which could have implications for knowledge sharing and awareness of agricultural technology and practices as well as market information.

Table 4-6: access to different services and facilities among smallholder farmers

	Non-Participants				Participants				Total			
	No		Yes		No		Yes		No		Yes	
Services and facilities	Frq.	%	Frq.	%	Frq.	%	Frq.	%	Frq.	%	Frq.	%
Access to credit	67	48.9	70	51.1	71	45.8	84	54.2	138	47.3	154	52.7
Have radio/television	24	17.5	113	82.5	22	14.2	133	85.8	46	15.8	246	84.3
Training on irrigation	25	18.3	112	81.8	42	27.1	113	72.9	67	23.0	225	77.1
Access to extension	52	38.0	85	62.0	62	40.0	93	60.0	114	39.0	178	61.0
Member of cooperative	1	0.7	136	99.3	4	2.6	151	97.4	5	1.7	287	98.3

Source: Field survey, 2023

Table 4.6 also presents the result regarding household heads' exposure to training on irrigation agriculture, 81.8% of non-participants and about 72.9% of participants have ever received such training. This suggests that there is a substantial portion of both participants and non-participants who have received training. This indicates that there is no target-specific special training for the farm households participating in small scale irrigation.

Further, the result on access to agricultural extension services the result shows a similar pattern, with 62.0% of non-participants and 60% of participants having access to these services although the service is indicated to be universal for all smallholder farmers. There are still a significant proportion of households without access to agricultural extension services.

Finally, looking into the cooperative membership presented in Table 4.6, the result reveals that 99.3% of non-participant and 97.4% of participant households reported to be part of a farmers' cooperative. This signifies that unless and otherwise, the farm households have another reason to opt out of the cooperatives they will be a member since access to agricultural inputs is mostly undertaken by these cooperatives in collaboration with respective farmers' cooperatives unions.

Table 4.7 presents the results on the distance to the household water source and market center in minutes for participants and non-participants in irrigation practices, along with the results of t-tests conducted to compare the mean values between the two groups. The mean distance from the household water source for non-participants is about 14.7 minutes with a standard deviation of 6.68, while for participants; it is 14.6 minutes with a standard deviation of 6.41.

The t-test result (t = 0.172) indicates that there is no significant difference in the mean distance to the water source between participants and non-participants in irrigation practice although the higher standard deviation indicates the presence of considerable within-group differences.

Table 4-7: distance to the household water source and market center in minutes

	Distance from water source in minutes			
Participation in irrigation practices	Obs.	Mean	Std. Dev.	t-test
Non-Participants	137	14.7	6.68	
Participants	155	14.6	6.41	t =0.172
Total	292	14.6	6.53	
	Distance from nearest market in minutes			
Non-Participants	137	35.1	14.85	
Participants	155	33.5	15.17	t =0.925
Total	292	34.3	15.02	

Source: Field survey, 2023

In terms of the distance from the nearest market center, non-participants have a mean distance of 35.1 minutes with a standard deviation of 14.85, while participants have a mean distance of 33.5 minutes with a standard deviation of 15.17. The t-test result (t = 0.925) suggests that there is also no significant difference in the mean distance to the market center between participants and non-participants which signifies proximity to these essential resources does not vary significantly based on participation in irrigation practice among the respondents of the study.

4.2Results of Inferential Statistics

4.2.1 Determinants of Small Scale Irrigation Participation among Households

Logistic regression is used to analyze relationships between a dichotomous dependent variable and independent variables. Logistic regression combines the independent variables to estimate the probability that a particular event will occur. In this study, logistic regression was performed to assess the determinants of independent variables on small scale irrigation participation. The estimated model coefficients cannot be interpreted directly but they tell us much about the direction and significance of the predictor variables. Hence, in this study the determinants are identified by using the coefficients, while the magnitude of influence is expressed using the odds ratio in the next section of this study.

Table: 4.8: Determinants of Small Scale Irrigation Participation

		Robust		
Participation	Coef.	Odds ratio	P>z	[95% Conf.
Age	0.048246	1.049429	0.311	-0.04518
Sex	-2.72451	0.065578	0.179	-6.69981
EDU_Year	-0.18871	0.828029	0.275	-0.52726
Fam_Size	1.855565	6.395313	0.007	0.504117
Landsize	-1.80006	0.165289	0.012	-3.20791
Livestock	-3.07113	0.046369	0.012	-5.46003
Acces_Credit	-0.8027	0.448117	0.439	-2.83456
Radio_TV	-0.38635	0.679533	0.675	-2.19132
Dis_Market	-0.12768	0.880137	0.003	-0.21265
Training_irrg	0.05441	1.055918	0.974	-3.15662
Agri_Extension	0.672737	1.959594	0.498	-1.27318

Source: Field survey 2023

The result revealed that assuming all other factors remains constant, a unit increase in family size of the respondents increases the likelihood of small scale irrigation participation by 6.395313 times. This may be because of the households' opportunity to get adequate family labor force to manage the irrigation practices.

The result further revealed that assuming all other factors remains constant, a unit increase in land size of respondent decreases the participation in small scale irrigation by 1.80006 times. This may be because of the farmer's perception that, they have relatively large amount of farm land that enables them to produce their best amount during the regular rainy season and may not give attention to small scale irrigation.

The binary logistic regression result revealed that assuming all other factors remains constant, respondents who have livestock resource, decreases the odds of small scale irrigation participation by 3.07113 times compared to those who have no livestock resources. The negative direction may be because of farmers spent time in caring their livestock resources after the regular rainy season.

Finally, the result revealed that assuming all other factors remains constant, a unit increase in distance from market decreases household participation in small scale irrigation by 0.880137 times. This may be because of it is difficult to access their perishable cultivated crops to the market place on the right time.

4.2.2 PSM Estimation Results

Small-scale irrigation has been practiced by many households in the area and is expected to have a multidimensional impact on farm households' consumption expenditure and multidimensional poverty status. To this end, the study has tried to single out the impact of small-scale irrigation in Bahir Dar Zuria Wereda on household consumption expenditure and multidimensional poverty status. In doing so, households that are participated in small-scale irrigation practice and those that did not participate were taken for comparative analysis through a consistent application of propensity score matching technique to understand the effect of the treatment i.e. participation in small-scale irrigation. The results are presented in the section below which are made to include the model fit assessment results at first and then attempt were made to present the final the treatment effect results.

Depending on final treatment effect results of the study firmly demand meeting the underlying assumptions of the PSM technique. The basic concept here in implementing the propensity score matching technique is to match small-scale irrigation participant households with identical or as much as possible small-scale irrigation non-participant households or control groups to enable comparison with smaller bias. Therefore, the balancing test, common support condition, and sensitivity test results with different test mechanisms are presented.

4.2.3 Model Test Results

4.2.3.1. Balancing Tests

The first step in implementing the propensity score matching technique is estimating the propensity scores of individuals, i.e., the probability of each individual participating in small-scale irrigation. This has been done by estimating the model of participation against observable **"*x*"** covariates independent of treatment assignment which were made to be age, sex, education level, family size, access to credit, land size, access to information, training, livestock ownership and extension service. The estimated propensity scores were tested for

satisfying the balancing property which is one of the assumptions to ensure that both in the treatment group and control group are balanced based on the estimated propensity scores.

The basic expectation here is that a randomized experiment balances the distributions of both observables and unobservable between treated and control samples, but PSM balances the distributions at each propensity score value which is estimated based on observable characteristics of households that are used as covariates during propensity score estimation process. Hence, the test verifies that treatment is independent of unit characteristics after conditioning on observed characteristics of households.

In the first place, the propensity score matching has succeeded in meeting the balancing property which balances the characteristics between treated and untreated groups. Then the common support has been decided. Based on this result, (detail in the annex) the estimated participation model shows that the balancing property is satisfied and the final number of blocks is 4 which are in line with the basic assumptions of the propensity score matching technique. Moreover, the result indicates that the common support region has been decided between [0.38857434, and 0.76815725].

Added to this, Table 4.8 presents a t-test of equality of means (covariate means) before and after matching that has been used by the study to evaluate the presence of any differences in the covariate means between the treatment and control groups and ensure the elimination of any differences if the problem existed after matching.

Table 4.8 displays the test results of the equality of mean of each covariate included in the model used to estimate the propensity score as well as serves as matching criteria between the control and treatment group which are tested before and after matching. The result indicated that the calculated t-statistics and/or p-value of the test turned into insignificant in most cases after matching to reflect the idea that the mean difference in covariates mean has been eliminated after matching and the result has been well improved.

This could be testified by evidences. Looking at the results, there have been significantly higher mean differences in the covariates of access to credit and livestock ownership before matching. After that one's result is conditioned to the propensity scores of individuals the mean difference has turned into an insignificant value which indicates the presence of equality of the average propensity score, or equality of the mean of each control variable, between treatment and comparison observations within quintiles of the propensity score. The acceptance of the null hypothesis in most of the cases from this test ensures that the balancing

property assumption has been met efficiently which could be considered as one step for undertaking treatment effect estimation on outcome variables since the samples were made similar as much as possible.

Table 4-8: T-test of equality of means before and after matching

Variable	Unmatched/ Matched	Mean		% bias	t-test	
		Treated	Control		t	p>t
Age	U	38.23	38.37	-1.2	-0.11	0.92
	M	38.29	38.37	-0.7	-0.06	0.95
Sex	U	0.79	0.80	-2.1	-0.18	0.86
	M	0.79	0.81	-6.4	-0.57	0.57
Educational Level	U	1.65	1.59	8.4	0.72	0.47
	M	1.64	1.61	4.5	0.40	0.69
Family Size	U	4.98	4.88	8.1	0.69	0.49
	M	4.96	4.86	7.8	0.69	0.49
Access to credit	U	1.41	1.31	15.7	1.34	0.18
	M	1.40	1.43	-4.2	-0.38	0.71
Land Size	U	0.77	0.77	0.3	0.03	0.98
	M	0.77	0.77	-0.8	-0.07	0.95
Access to information	U	0.54	0.51	6.2	0.53	0.60
	M	0.55	0.52	5.8	0.51	0.61
Training	U	0.86	0.82	9.1	0.78	0.44
	M	0.86	0.87	-4.4	-0.42	0.68
Livestock Ownership	U	0.73	0.82	-21.2	-1.80	0.07
	M	0.73	0.73	1.6	0.13	0.90
Extension service	U	0.60	0.62	-4.2	-0.36	0.72
	M	0.60	0.59	2	0.17	0.86

Source: Field survey, 2023

Moreover, the study has tried to evaluate the result of the chi2 test of joint significance of variables to visualize the reduction in overall mean bias after matching which is displayed in Table 4.9. The result shows that there exists significant reduction in the mean bias value where the mean bias value falls from a 7.6 to 3.8 and the median bias fails from 7.1 to that of 4.3.

Table 4-9: A chi-square test of joint significance of variables

Sample	Ps R2	LR chi2	p>chi2	Mean Bias	Med. Bias
Unmatched	0.015	6.13	0.804	7.6	7.1
Matched	0.005	2.06	0.996	3.8	4.3

Source: Field survey, 2023

As indicated in Table 4.9, the result of the likelihood ratio chi-square test fails to reject the null hypothesis after matching as manifested by insignificant p-value before matching and also after matching. This indicates the absence of significant mean bias that could affect the overall result or the estimated treatment effect.

4.2.3.2. The Common Support Condition

The other assumption in PSM is common support assumption that demands the presence of sizable common support region to work appropriately. If the matching estimators need to identify and consistently estimate the treatment effect of participation in irrigation on the outcome variables. This assumption needs to be well met. The basic thing considered here is the ideas of comparing comparable subjects rather that comparing individuals with different characteristics by finding a control group match for each treated group with relatively similar propensity score since estimating the propensity scores only cannot be taken as an end result to estimate the average treatment effect.

In principle, the common support assumption considers that the probability of participation in an intervention, conditional on observed characteristics, lies between 0 and 1 ($0< P (D=1/x) < 1$). This assumption is critical to estimation; as it ensures that units with the same X values have a positive probability of participate in irrigation in this study. If $p (X) = 0$ or $p(X) = 1$ for values of X, then we cannot use matching conditional on those X values to estimate treatment effect, because persons with such character either always or never receive treatment, meaning that, they may always participate in irrigation or never participate in irrigation as an extreme value. Hence, the common support condition (overlap) fails and matches cannot be performed.

Evaluation of the presence of sizable common support condition could be done by different techniques. One is that visual inspection of the minimum and maximum propensity score distributions for both the treatment and comparison groups to examine whether the values lie within the common support region or not. The estimated propensity scores for all individuals from treated and controlled groups lies within the identified common support region of the study which is between [.38857434 and .76815725].

Similarly, the second method used in this study to examine the presence of sizable common support region is to undertake the propensity sore matching technique to estimate treatment effect is visual inspection of the propensity score or common support graph of both treated and non-treated groups which is presented in Figure 4.

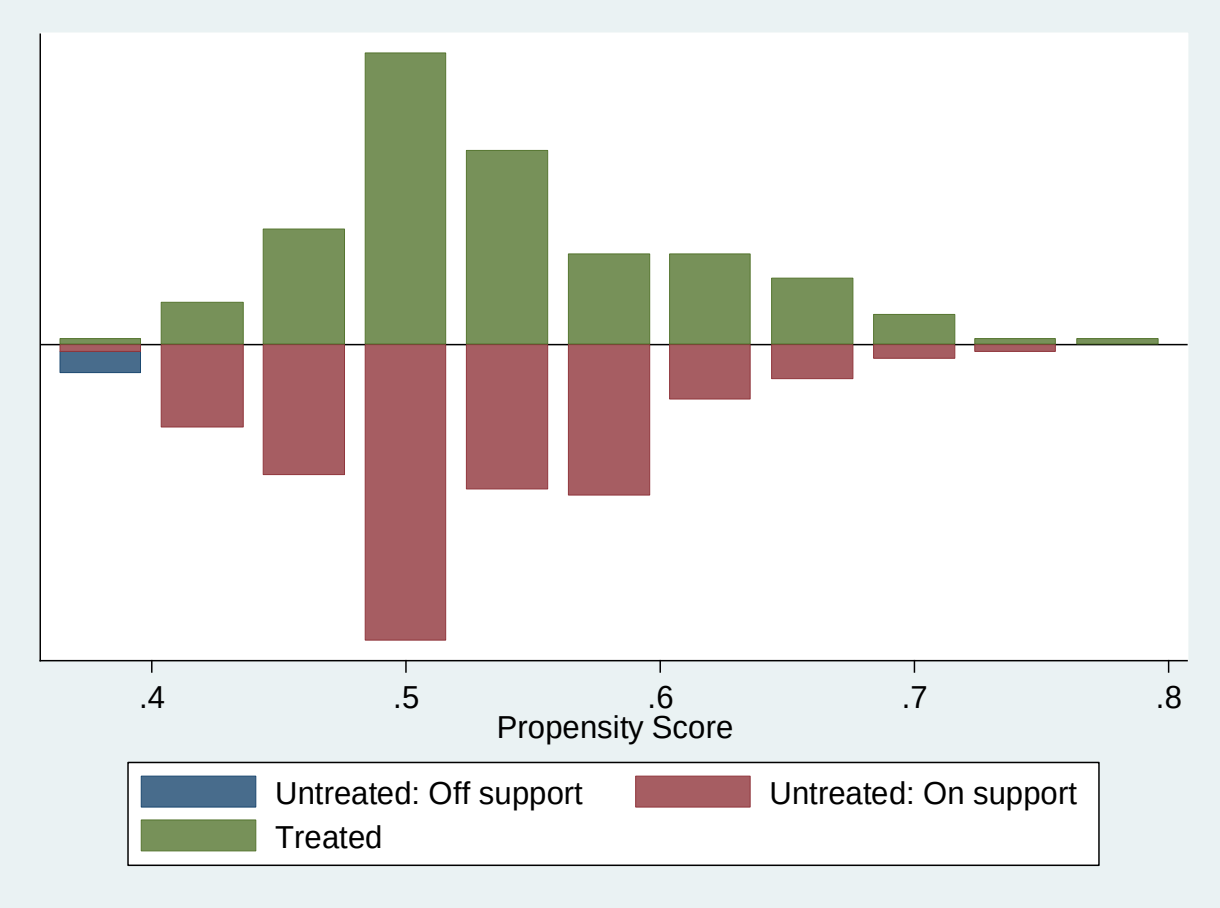


Figure 4 : The region of common support

The above graph demonstrated that there is dependable region of common support that meet the assumption and indicated the presence of large number of treated and control groups which are matched. Hence, the visual inspection of common support region signifies the presence of sufficient samples within common support region to estimate the treatment effect on the treated.

Moreover, evaluation of the matched samples based on their propensity scores revealed that out of 155 treated group households and 137 control group households 154 treated group (participants) samples were matched to 137 samples from the control groups (non-participants). The result shows the presence of sufficient number of study participants from both control and treatment with relatively similar propensity scores estimated based on

observable characteristics. Relaying on the results, the estimation of treatment effect was based on such matched samples.

In order to provide clear visual observation on the distribution of propensity scores across treatment and control group, the study applies kdnesity graph of propensity scores before and after matching. As displayed in Figure 5 there has been some observed difference in the distribution of propensity scores of treated and control groups before matching as demonstrated in the distribution graph of both groups. Then after, the gap in distribution of propensity scores of control and treatment groups has been significantly reduced to show the presence of propensity scores distribution.

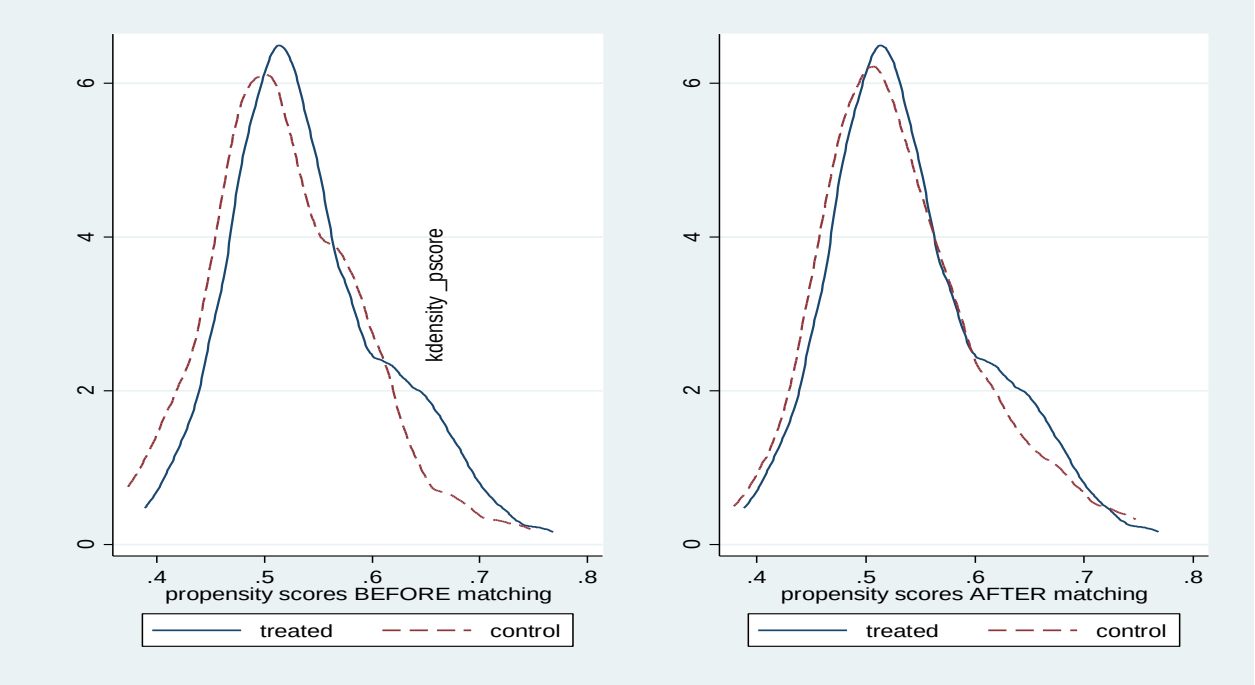


Figure 5: Kdensity graph of propensity scores of groups before & after matching

4.2.3.3. Sensitivity Test Result

The last model fit test undertaken by the study is sensitivity test used to evaluate the sensitivity of estimated results as a result of deviation from assumptions of the estimation technique (PSM). It checks whether hidden biases affect the result or not with respect to the choice of balancing score. Hidden bias may occur in case if there are unobservable variables that affect treatment assignment and outcome simultaneously which may have a greater influence on the final estimated treatment effect. To check the estimated treatment effect do not suffer from hidden bias that may affect the final estimated effect, the study has employed

Rosenbaum sensitivity analysis for average treatment effects on the treated using rbounds command in STATA where the test results for the two outcome variables were attached as annex.

In presence of unobserved heterogeneity or hidden bias the test calculates Rosenbaum bounds for average treatment effects by taking the difference in the response variable between treatment and control cases as input variable using matched pairs only. The test has been run with a null hypothesis which states that distributions of outcome variables are the same among the matched pairs of treatment and control groups. The final test result, as indicated in the annex part of this study, support the fact that there is an observed significant mean difference in outcome variables which could be taken as a base for the rejection of the presence of considerable hidden biases that affect the estimated results or treatment effect.

```
. rbounds rho, gamma(1(0.05)2)

Rosenbaum bounds for rho (N = 154 matched pairs)

Gamma             sig+        sig-     t-hat+     t-hat-         CI+         CI-
-------------------------------------------------------------------------------
    1          .000276    .000276    1015.53    1015.53    443.071    1713.69
 1.05          .000705       .0001    939.163    1104.17     369.79    1806.25
  1.1          .001614    .000036    868.359    1183.33    295.352    1901.15
 1.15          .003364    .000012    797.554    1268.65    218.598    1988.13
  1.2          .006456    4.3e-06     738.54    1348.71     144.48    2078.77
 1.25          .011528    1.4e-06    669.529    1424.59    90.3682       2150
  1.3          .019315    4.8e-07     607.54    1502.13    33.3751    2227.64
 1.35          .030592    1.6e-07    551.668    1569.63   -20.8301    2309.48
  1.4          .046091    5.1e-08      497.5    1643.44   -72.0312     2377.7
 1.45          .066425    1.6e-08     441.25    1720.42   -125.098    2449.16
  1.5          .092007    5.2e-09    388.487    1781.74   -176.045    2510.42
 1.55          .122999    1.7e-09    341.247    1842.19   -221.348    2591.25
  1.6          .159287    5.2e-10    292.491    1905.42   -272.919    2655.05
 1.65           .20048    1.6e-10    240.409    1962.18   -314.902    2717.71
  1.7          .245941    5.0e-11    189.062    2025.21   -362.141    2781.98
 1.75          .294841    1.6e-11    142.815    2080.18   -403.446     2844.2
  1.8          .346217    4.8e-12    110.779    2126.52     -437.5    2906.62
 1.85          .399042    1.5e-12    77.7344    2176.59     -477.6    2962.13
  1.9          .452292    4.4e-13    36.6588       2224   -517.449    3026.98
 1.95          .504999    1.3e-13   -2.24606    2279.84   -547.661    3082.24
    2          .556295    4.0e-14   -37.6612    2325.03   -583.333    3130.94

* gamma  - log odds of differential assignment due to unobserved factors
  sig+   - upper bound significance level
  sig-   - lower bound significance level
  t-hat+ - upper bound Hodges-Lehmann point estimate
  t-hat- - lower bound Hodges-Lehmann point estimate
  CI+    - upper bound confidence interval (a=   .95)
  CI-    - lower bound confidence interval (a=   .95)

. rbounds rho1, gamma(1(0.05)2)

Rosenbaum bounds for rho1 (N = 154 matched pairs)

Gamma             sig+        sig-     t-hat+     t-hat-         CI+         CI-
-------------------------------------------------------------------------------
    1          1.6e-07    1.6e-07       -.25       -.25       -.25       -.25
 1.05          4.3e-08    5.6e-07       -.25       -.25       -.25       -.25
  1.1          1.1e-08    1.7e-06       -.25       -.25       -.25       -.25
 1.15          2.9e-09    4.9e-06       -.25       -.25         -.5       -.25
  1.2          7.5e-10    .000012       -.25       -.25         -.5  -4.4e-07
 1.25          1.9e-10    .000029       -.25       -.25         -.5  -4.4e-07
  1.3          4.9e-11    .000062       -.25       -.25         -.5  -4.4e-07
 1.35          1.2e-11    .000125       -.25       -.25         -.5  -4.4e-07
  1.4          3.1e-12    .000239       -.25       -.25         -.5  -4.4e-07
 1.45          7.9e-13    .000433       -.25       -.25         -.5  -4.4e-07
  1.5          2.0e-13     .00075       -.25       -.25         -.5  -4.4e-07
 1.55          5.0e-14    .001243       -.25       -.25         -.5  -4.4e-07
  1.6          1.2e-14    .001984       -.25       -.25         -.5  -4.4e-07
 1.65          3.1e-15    .003057         -.5       -.25         -.5  -4.4e-07
  1.7          7.8e-16    .004563         -.5       -.25         -.5  -4.4e-07
 1.75          2.2e-16    .006618         -.5  -4.4e-07         -.5  -4.4e-07
  1.8                0    .009346         -.5  -4.4e-07         -.5  -4.4e-07
 1.85                0    .012881         -.5  -4.4e-07         -.5  -4.4e-07
  1.9                0     .01736         -.5  -4.4e-07         -.5  -4.4e-07
 1.95                0    .022921         -.5  -4.4e-07         -.5  -4.4e-07
    2                0    .029694         -.5  -4.4e-07         -.5  -4.4e-07

* gamma  - log odds of differential assignment due to unobserved factors
  sig+   - upper bound significance level
  sig-   - lower bound significance level
  t-hat+ - upper bound Hodges-Lehmann point estimate
  t-hat- - lower bound Hodges-Lehmann point estimate
  CI+    - upper bound confidence interval (a=   .95)
  CI-    - lower bound confidence interval (a=   .95)
```

4.2.4 Impact of Small-Scale Irrigation on Household Consumption Expenditure

The practice of small-scale irrigation has been deeply rooted in the study area, serving as a crucial livelihood strategy for households. Its multifaceted benefits range from providing food staples for household consumption to cultivating cash crops, thus bolstering household income and influencing living condition and agriculture. To understand its impact on households, this study examines the impact of participation in irrigation on key outcome variable, including household consumption expenditure and multidimensional poverty status.

Initially, focusing on household monthly consumption expenditure, quantified as the expenditure in Ethiopian Birr (ETB) per month on food, non-food, and drinking items, the findings underscore a significant impact of small-scale irrigation on household consumption expenditure. Utilizing three matching algorithms—Nearest Neighbor, Radius and Kernel Matching—the study estimates the average treatment effect (ATE) of irrigation participation on household consumption expenditure. The results, analyzed at a 95% confidence level, consistently reveal a positive average treatment effect (ATE), indicating that households engaged in small scale irrigation experience notably higher consumption expenditure.

Table 4-10: Estimated average treatment effect of participation in small scale irrigation scheme on household monthly consumption expenditure

Matching Methods	Obs. Treated	Obs. Control	ATE	Str. Err.	T
Nearest Neighbour matching	155	84	1,359.28	452.23	3.01
Radius Matching	154	134	1,395.07	355.30	3.93
Kernel Matching	155	134	1395.985	291.60	4.79

Source: Field survey, 2023

The results consistently demonstrate a significant positive impact on household consumption expenditure across different matching algorithms. Notably, estimated ATE signifies an average increase in monthly consumption expenditure of approximately 1,359.28 ETB (t=3.01) for Nearest Neighbor matching, 1,395.07 ETB (t=3.93) for Radius matching, and 1,395.98 ETB (t=4.79) for Kernel matching compared to non-participant households. This substantial increase in expenditure emphasizes the profound influence of small-scale irrigation participation on household livelihoods.

This improvement can be attributed to the economic empowerment facilitated by small scale irrigation participation, allowing households to allocate more resources toward fulfilling their basic needs and aspirations, thereby enhancing their quality of life. Consequently, households engaged in small-scale irrigation exhibit enhanced economic resilience and improved welfare outcomes, reflecting the transformative potential of such farming practices on rural livelihoods.

4.2.5 Impact of Small-Scale Irrigation on Household Multidimensional Poverty

The study begins by assessing household deprivation status before identifying multidimensional poor households among participants and non-participants in irrigation. This initial assessment involves examining various indicators of poverty within households. Table 4.11 presents the findings, indicating the percentage of households unable to meet the minimum thresholds set for each indicator of multidimensional poverty. This helps determine the level of achievement necessary for a household to be considered non-deprived in each area (Alkire & Foster, 2009).

The results reveal high levels of deprivation in living standards and education. A significant proportion of households (36.04%) lack access to clean water, while many experiences have limited or no access to formal schooling (21.58%) of the households. Notably, about a quarter of households are without access to safe drinking water within a reasonable distance from their homes. Despite this, the study area demonstrates slightly better access to safe drinking water compared to the national average, though the proportion of deprived households remains concerning. These findings are consistent with a prior study conducted in 2018 by Koyachew, Bamlak, and Assefa, indicating a persistent issue with water access.

Table 4-11: Crude deprivation rates of households by indicators (%)

Domain	Indicator	Weight	Deprivation (%)
Education	Year of schooling	0.17	21.58%
	Child enrollment	0.17	15.07%
Health	Mortality	0.17	16.10%
	Morbidity	0.17	16.44%
Living standard	Water	0.17	36.64%
	Housing	0.17	13.70%

Source: Field survey, 2023

The result in Table 4.11 also provides a detailed breakdown of deprivation rates for specific indicators such as child enrollment, mortality, morbidity, and housing. It reveals the extent of deprivation in each area, with child enrollment deprivation at approximately 15.07%, and mortality and morbidity deprivation rates are 16.10% and 16.44% respectively. Interestingly, housing deficiency appears to be comparatively lower, with only 13.7% of households experiencing deprivation in this aspect.

Overall, despite some improvement compared to previous studies, the overall deprivation rate in the study area remains high. Therefore, interventions are necessary to address these challenges, with a specific emphasis on increasing engagement in small-scale irrigation practices which could be a potential solution.

4.2.6 Household Multidimensional Poverty Status

Table 4.12 offers a comprehensive view of the poverty profile among households, distinguishing between those participating in irrigation practices and those who are not. The adjusted headcount ratio reveals that multidimensional poverty in the study area is estimated to be approximately 15.3%. This suggests that each MPI poor household experiences multiple deprivations simultaneously, making them as multidimensional poor. The disaggregated results between the subgroups show that around 9.4% of irrigation practice participants and 22% of non-participants fall into this multidimensional poor households' category. The findings further underscore the significant impact of irrigation practices on household poverty profiles. Participation in such practices often enables families to escape poverty by enhancing income capacity and food security, thereby contributing to an improved standard of living among farm households.

Table 4-12: Household's Multidimensional Poverty by participation in irrigation practice

Item Description	Participants in Irrigation		Total
	Non-Participants	Participants	
Non-poor households (MPI <= 30.0%)	49.6%	77.4%	64.4%
Poor households (H)	50.4%	22.6%	35.6%
Poverty intensity rate (A) of the study area			42.9%
Multidimensional poor households (MO) = (H*A)	22.0%	9.4%	15.3%

Source: Field survey, 2023

Regarding the contribution to the multidimensional poverty profile of households, access to safe drinking water emerges as a primary factor. Approximately (21.5%) of non-participating households in small-scale irrigation practices and (31%) of participating households cite this as a significant deprivation contributor. Further analysis based on the subgroup's contribution to multidimensional poor households reveals that (67.5%) of multidimensional poor households were from non-participants in irrigation practices, while (32.5%) of them were from participants.

4.2.6.1. Average Treatment Effect of SSI on Household Multidimensional Poverty

The study before estimation of ATE of irrigation practice, the households was classified as multidimensional poor (1) and non-poor (0) based on the estimated poverty index indicated in the above sessions. Table 4.13, presents and focusing on the estimated ATE of participation in small scale irrigation practice on household multidimensional poverty which reveals significant insights into the impact of irrigation on poverty alleviation.

The result across various matching methods employed, including Nearest Neighbor, Radius, and Kernel Matching, a consistent trend emerges and participation in small-scale irrigation demonstrates a negative average treatment effect on household multidimensional poverty. Notably, the negative values suggest that households engaged in irrigation experience a reduction in multidimensional poverty compared to non-participating households which is found to be significant at 5% level as demonstrated by the t-values. Despite slight variations in the estimated treatment effects among matching techniques, the overarching pattern remains consistent, affirming the beneficial impact of irrigation on poverty. The result shows moderate to strong effect, ranging from -0.19 to -0.29, which indicates household participated in small scale irrigation on average experience a 19% to 29% reduced probability of multidimensional poverty.

Table 4-13: Average treatment effect of SSI on Household multidimensional poverty

Matching Methods	Obs. Treated	Obs. Control	ATT	Str. Err.	T
Nearest Neighbour matching	155	84	-0.19	0.08	-2.59
Radius Matching	154	134	-0.29	0.06	-4.81
Kernel Matching	155	134	-0.28	0.05	-5.21

Source: Field survey, 2023

Overall, the result implicates the presence of tangible and meaningful improvement in household well-being attributed to irrigation engagement. Hence, small-scale irrigation initiatives not only contribute to enhancing agricultural productivity and income generation but also play a pivotal role in addressing broader dimensions of poverty, such as food security, health, and education.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1Conclusions

The study tried to investigate the impact of participation in small scale irrigation on household multidimensional poverty status where overall general characteristics in irrigation practice, its impact on household consumption expenditure and multidimensional poverty profile of farm households in Bahir Dar Zuria Woreda were examined.

The study, with approximately 53.1% of respondents actively engaged in irrigation activities, reveal that Potatoes, tomatoes, and maize production emerged as the top crops cultivated through irrigation, reflecting local preferences and crop suitability. Participation in the small-scale practice also significantly improve the number of productions per year by farm households as it provides the opportunity and access to irrigable land both in the rainy and dry season. Moreover, small scale irrigation participation is positively affected by family size, while land size, livestock ownership and distance from market sites negatively affect small scale irrigation participation.

Importantly, participation in small-scale irrigation positively impacted household consumption expenditure, where household participating in irrigation practice have relatively higher consumption expenditure. Hence, indicating economic empowerment facilitated by irrigation practices which further lead to better living standard among the farm households. Furthermore, irrigation participation was associated with reduced multidimensional poverty status among farm households, highlighting the role of irrigation in poverty alleviation. Through multidimensional poverty analysis, it is revealed that approximately 22% of non-participant households experience multiple deprivations which make them multidimensional poor while the result is much less than more than by half for the irrigation practice participant household.

The result also testified by the average treatment effect result from the PSM estimate which clearly demonstrated irrigation participants exhibit a lower incidence of multidimensional poverty compared to non-participants, indicating the positive influence of such practices on poverty alleviation. Among other indicators, access to safe drinking water emerges as a significant factor contributing to household poverty status.

Overall, the findings underscore the importance of irrigation practices in enhancing income capacity, food security, and overall living standards which is directly attributed to lower level of exposure to multidimensional poverty among farm households.

5.2Recommendations

Based on the key findings and conclusion of this study on the impact of small scale irrigation on households' multidimensional poverty, the following recommendations are forwarded to address the identified issues and leverage the potential of small-scale irrigation for household multidimensional poverty reduction:

Small scale irrigation participation is found to be the key in reducing exposure to household multidimensional poverty among farm households. Hence, local government and interested development agencies should implement targeted programs to encourage and support farmers' participation in small-scale irrigation practices where the programs could include providing technical assistance, improving access to irrigable land and affordable irrigation technologies, and training on efficient water management techniques.

Family size and small scale irrigation are positively related as larger households may have more labor to participate in irrigation. Thus, households that have relatively bigger family size are advised to increase their engagement on the small scale irrigation which can reduce household multidimensional poverty.

Extensive training and awareness creation is needed to gear those households with large land size and livestock holding to engage in small scale irrigation practice to reduce multidimensional poverty at household level. Market linkage and supply chain infrastructures are also needed.

Among indicators of household multidimensional poverty access to 'safe drinking water' was found to be the main player and contribute of deprivation in the household multidimensional poverty index of both irrigation practice participants and non-participants. Therefore, efforts should be made to improve access to safe drinking water, particularly in areas where households face significant deprivation by involving in packages like infrastructure development for water supply and the rehabilitation of existing water sources.

Households with better consumption expenditure which are mostly from those practicing small-scale irrigation are found to be less affected by multidimensional poverty which could be attributed to better spending for improved living conditions. Hence, local authorities

should think beyond irrigation and made efforts to diversify livelihood to other economic opportunities for such rural households.

Finally, this study recommends for supportive government policies and subsidies to promote small-scale irrigation development in rural areas to reduce rural household multidimensional poverty. Further, engage those stakeholders, including policymakers, Non-Governmental Organizations, and development agencies at different level, to prioritize investments in irrigation as a tool for poverty reduction.

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ANNEXES

Addis Ababa University

College of Development Studies

Annex 1: Structured Questionnaire

Dear/Sir/Madam

This is a structured questionnaire prepared to undertake a study entitled "Impact of Small-Scale Irrigation on Household Multidimensional Poverty in Bahir Dar Zuria Woreda, North West Ethiopia"

Dear respondent, I am a post graduate student in the Center of Rural Development Studies, College of Development Studies, Addis Ababa University. Currently, I am planning to undertake a research in order to complete the requirements for Master Arts Degree in Development Studies (Rural Livelihood and Development Studies). The research is conducted purely for academic purpose and all the information given are treated as confidential and will not be used for other purposes.

I also assure you that no personal identity will be disclosed to third parties. I am so grateful to you by giving reliable and appropriate data and information.

Thank you for your time

Code ----------

Date of interview ----------

1. **Are you participating in small-scale irrigation activities?**
    a. No
    b. Yes

I. Socio-Demographic Characteristics

S.N	Items	Options
1.1.	What is your age in years?	----------
1.2	Sex of the household head?	Female Male
1.3	What is your educational status?	a. Illiterate b. Read and write c. Formal Education
1.4	If your answer for question number 1.3 is formal education, what is your highest year of schooling completed?	----------
1.5	What is your family size?	----------
1.6	Family members under the age of 15?	----------
1.7	Family members from the age of 15 – 64?	----------
1.8	Family members above the age of 64?	----------

1.9. How much is the size of your total farmland in hectares? ----------

1.10. How many times you produce per year? ----------

II. Irrigation Practice Related Characteristics

2.1 How much of your land is irrigated in hectare? ----------

2.2 Do you have livestock's?

A. Yes B. No

2.3 What are the crops you produce through irrigation?

Irrigated crop	Size of land in hectare	How many times you produce	Source of water
Teff			
Wheat			
Maize			
Potato			
Others (specify)			

III. Household Heads Access Related Characteristics

S.No	Items	Options
3.1	Do you have access to credit from formal financial institutions?	No Yes
3.2	Do you have radio/television?	No Yes
3.3	How far your land is located from water source in minutes?	----------
3.4	Have you ever get trainings on irrigation agriculture?	No Yes
3.5	Do you have access to agricultural extension service?	No Yes
3.6	Are you member of farmers' cooperative in your area?	No Yes

IV. Household Food and Non-Food Consumption Expenditure

4.1 What is your staple (frequently consumed) food? _____

4.2 From where do you get these food stuffs?

A. Self-production C. Purchased from market

C. Borrowed from relatives D. Other specify _____

4.3 Fill the type, quantity and price of each food and non-food items (monthly average)

S.N	Monthly food, drink & non-food item base	Amount in kg, liter/unit	Price per kg/litter in birr
1.	**Food Items**		
1.1	Teff		
1.2	Sorghum		
1.3	Barley		
1.4	Wheat		
1.5	Maize		
1.6	Potato		
1.7	Tomato		
1.8	Dry pepper		
1.9	Edible Oil/lit		

1.10	Sugar		
1.11	Onion		
1.12	Bean		
1.13	Pea		
1.14	Lentil		
1.15	Meat		
1.16	Egg		
2	**Drinking**		
2.1	Milk		
2.2	Beer (all type)		
2.3	Local drink (Tela, Caticala)		
2.4	Soft Drink		
2.5	Coffee		
2.6	Others specify _____		
3	**Non-Food items**		
3.1	Basic services (Mobile phone & Electric)		
3.3	Transport		
3.4	Clothes and shoes (in Birr/year))		
3.5	Expenditure on Education (in Birr/ year)		
3.6	Health Expenditure (in Birr/ year)		
3.7	Ceremony (weeding, holiday etc/year)		
3.8	Kerosine		
3.9	Firewood		

4.4. In which season your expenditure is high?

A. Winter B. Summer C. Autumn D. Spring

4.5 On average, how many times you eat per day this year?

A. Once B. Twice C. Three D. More than 3 times

V. Multidimensional Poverty Dimensions and Indicators

S.No	Dimensions & Indicator	Items	Options
5.1	**Education**		
	Year of schooling	No household member has completed any level of formal schooling	No Yes
	Child enrollment	Any school-aged child is not attending school	No Yes
5.2	**Health**		
	Mortality	Child has died in the household in the past five years prior to the survey	No Yes
	Morbidity	Does any household member experiencing illness in the previous month prior to the survey?	No Yes
5.3	**Living standard**		
	Water	Does the household have access to clean drinking water?	No Yes
	Housing	The household has mud, wood, thatch (sar) roof.	No Yes

Annex 2: Key Informant Interview

1. What is the effort of your office in expanding small-scale irrigation infrastructure?
2. What sort of support you provide to household heads to expand small scale irrigation?
3. Is there any market linkage for irrigation products? Explain how?

Thank you in advance for your time!

Annex 3: Detail Estimated Outputs from STATA

```
. pscore Participation Age Sex Edu Fam_Size Landsize Livestock Acces_Credit Radio_TV Training_irrg
> Agri_Extension, pscore(MYPS) blockid(blockf1) comsup level(0.001)

**************************************************
Algorithm to estimate the propensity score
**************************************************

The treatment is Participation
```

Are you participating in small-scale irrigation activities?	Freq.	Percent	Cum.
No	137	46.92	46.92
Yes	155	53.08	100.00
Total	292	100.00	

```
Estimation of the propensity score

Iteration 0:   log likelihood = -201.84383
Iteration 1:   log likelihood = -198.77949
Iteration 2:   log likelihood =  -198.7777
Iteration 3:   log likelihood =  -198.7777

Probit regression                                 Number of obs   =        292
                                                  LR chi2(10)     =       6.13
                                                  Prob > chi2     =     0.8040
Log likelihood =  -198.7777                       Pseudo R2       =     0.0152
```

Participat~n	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Age	-.0011277	.0067229	-0.17	0.867	-.0143042	.0120489
Sex	.00463	.1846801	0.03	0.980	-.3573364	.3665964
Edu	.0688747	.106722	0.65	0.519	-.1402966	.278046
Fam_Size	.0394623	.0590245	0.67	0.504	-.0762236	.1551482
Landsize	.1172045	.1142502	1.03	0.305	-.1067218	.3411307
Livestock	-.0034161	.1765637	-0.02	0.985	-.3494746	.3426424
Acces_Credit	.0437499	.1519873	0.29	0.773	-.2541397	.3416395
Radio_TV	.119618	.2087505	0.57	0.567	-.2895254	.5287615
Training_i~g	-.3012155	.1881757	-1.60	0.109	-.670033	.067602
Agri_Exten~n	-.010357	.1617452	-0.06	0.949	-.3273718	.3066577
_cons	-.2304014	.5485359	-0.42	0.674	-1.305512	.8447091

```
Note: the common support option has been selected
The region of common support is [.38857434, .76815725]

Description of the estimated propensity score
in region of common support

                    Estimated propensity score
      Percentiles      Smallest
 1%     .4053045       .3885743
 5%     .4304596        .399279
10%     .4491341       .4053045       Obs                 289
25%      .487555       .4057683       Sum of Wgt.         289

50%     .5168906                      Mean           .5322855
                       Largest        Std. Dev.      .0704891
75%     .5748599        .718369
90%     .6368425       .7403624       Variance       .0049687
95%     .6631859       .7468388       Skewness       .6532655
99%     .7403624       .7681573       Kurtosis       3.316756

**************************************************
Step 1: Identification of the optimal number of blocks
Use option detail if you want more detailed output
**************************************************

The final number of blocks is 4

This number of blocks ensures that the mean propensity score
is not different for treated and controls in each blocks

**********************************************************
Step 2: Test of balancing property of the propensity score
Use option detail if you want more detailed output
**********************************************************

The balancing property is satisfied

This table shows the inferior bound, the number of treated
and the number of controls for each block
```

Inferior of block of pscore	Are you participating in small-scale irrigation activities? No	Yes	Total
.2	1	1	2
.4	117	121	238
.6	16	33	49
Total	134	155	289

```
Note: the common support option has been selected

******************************************
End of the algorithm to estimate the pscore
******************************************
```

The result of matching groups and evaluating the number of samples on and off support

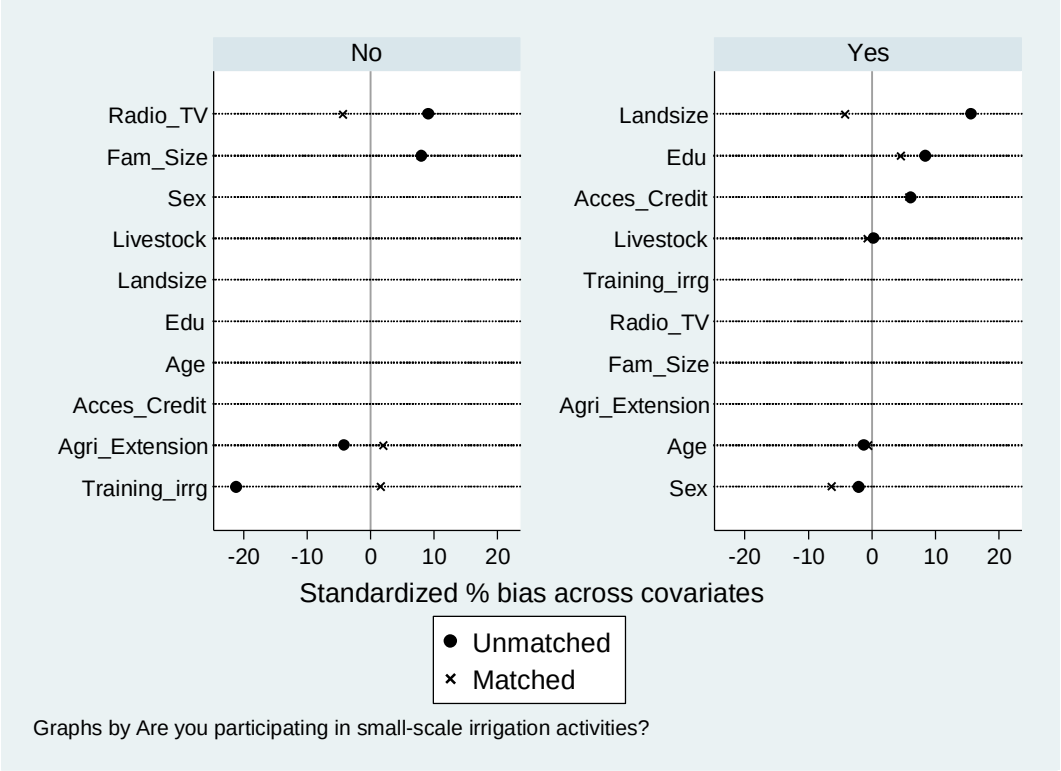
```
. psmatch2 Participation, outcome(ConsuExp MPI_H) p(MYPS) n(2) common cal(.01796635)
```

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
ConsuExp	Unmatched	7060.956	5750.17201	1310.78398	336.977577	3.89
	ATT	7067.03363	5732.55162	1334.48201	397.597557	3.36
MPI_H	Unmatched	.225806452	.503649635	-.277843183	.053933139	-5.15
	ATT	.227272727	.457792208	-.230519481	.067876843	-3.40

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support		Total
	Off suppo	On suppor	
Untreated	0	137	137
Treated	1	154	155
Total	1	291	292

Graphical representation of the ps-test result



Multidimensional Poverty Estimate detail results

```
. mpi d1(MPI_EDU_year MPI_EDU_Child) d2(MPI_ChildDied MPI_illness
> Water MPI_Roof), cutoff(0.3) by (Participation)
```

Summary of mpi indicators

Indicator	Type	Weight	Deprived
Domain 1			
MPI_EDU_year	Binary	.17	21.575 %
MPI_EDU_Child	Binary	.17	15.068 %
Domain 2			
MPI_ChildDied	Binary	.17	16.096 %
MPI_illness	Binary	.17	16.438 %
Domain 3			
MPI_DrinkingWater	Binary	.17	36.644 %
MPI_Roof	Binary	.17	13.699 %

Deprived: Percentage of individuals whose indicator values are below the threshold.

Main results N = 292

	Coef.	Std. Err.	[95% Conf.	Interval]
Main				
H	0.356	0.028	0.301	0.411
M0	0.153	0.013	0.128	0.178
Additional				
A	0.429	0.014	0.403	0.456

Note: Adjusted Multidimensional Headcount M0 = H*A

Indicator	M0
domain 1	
MPI_EDU_year	0.157
MPI_EDU_Child	0.160
domain 2	
MPI_ChildDied	0.175
MPI_illness	0.116
domain 3	
MPI_DrinkingW~r	0.246
MPI_Roof	0.146
Total	1.000

Contribution of each indicator (%)

Domain	M0
domain 1	0.317
domain 2	0.291
domain 3	0.392
Total	1.000

Contribution of each domain (%)

Decomposition by subgroups

MPI by: Participation

	No	Yes	Total
H	0.504	0.226	0.356
M0	0.220	0.094	0.153
pop share	0.469	0.531	1.000

Indices by subgroup (absolute)

	No	Yes	Total
H	0.663	0.337	1.000
M0	0.675	0.325	1.000

Contribution of subgroups to indices (%)

	No	Yes	Total
M0			
MPI_EDU_year	0.160	0.149	0.157
MPI_EDU_Child	0.193	0.092	0.160
MPI_ChildDied	0.182	0.161	0.175
MPI_illness	0.072	0.207	0.116
MPI_DrinkingWa~r	0.215	0.310	0.246
MPI_Roof	0.177	0.080	0.146
Total	1.000	1.000	1.000

Contribution of each indicator (%)

	No	Yes	Total
M0			
domain 1	0.354	0.241	0.317
domain 2	0.254	0.368	0.291
domain 3	0.392	0.391	0.392
Total	1.000	1.000	1.000

Contribution of each domain (%)

Type ereturn list to see the list of saved results and mc information on the estimation sample.