Modeling Inclusive Green Growth and Sustainable Finance through Ecotax:

The Application of the System Dynamics Model in Ethiopia

A Thesis Submitted in Partial Fulfillment of the Requirements of the Master of Science Degree in Economics Specialization in Applied Economic Modeling

By: Demessie Dea

Advisor: Zerayehu Sime (Ph.D.)

June 2023

Addis Ababa University

College of Business and Economics

Department of Economics

This is to certify that the thesis prepared by Demessie Dea, entitled: ***"Modeling Inclusive Green Growth and Sustainable Finance through Ecotax: The Application of the System Dynamics Model in Ethiopia"*** and submitted in partial fulfillment of the requirements for the degree Masters of Science in Economics: Specialization in Applied Economic Modeling complies with the regulations of the University and meets the accepted standards concerning originality and quality.

Signed by the Examining Committee:

External Examiner _____ Signature_____ Date _____

Examiner _____Signature_____ Date _____

Advisor: Dr. Zerayehu Eshete (Associate Professor) _____Date _____

Declaration

I, Demessie Dea, declare that this thesis entitled ***"Modeling Inclusive Green Growth and Sustainable Finance through Ecotax: The Application of the System Dynamics Model in Ethiopia"*** is an outcome of my effort except those which are duly cited and quoted. This study has not been submitted for any degree in this University or any other University. It is offered for the partial fulfillment of the degree of Masters of Science in Economics: Specialization in Applied Economic Modeling.

Declared by:

Name: Demessie Dea

Signature ----------

Date ----------

Confirmed by Advisor:

Name: **Dr. Zerayehu Eshete (Associate Professor)**

Signature ----------

Date ----------

Place and date of submission: Addis Ababa University June 2023

Acknowledgment

I would like to take this opportunity to give an immense thank you to the department professors who have showed us the utmost level of self-discipline and professionalism during our study duration. Special thanks to my advisor Dr Zerayehu Eshete an epitome of human being who has supported me during the course work and as my advisor. I have nothing but respect for everyone who has supported me through this incredible journey.

“Ease is the Greatest Threat to progress”

List of Tables **Pages**

List of Figures

List of Acronyms

AFOLU:	**Agricultural, Forestry and Land Use**
ADB:	**African Development Bank**
BAU:	**Business as Usual**
CRGE:	**Climate Resilient Green Economy**
GDP;	**Gross National Product**
GWH;	**Giga What Hour**
IGG;	**Inclusive Green Growth**
NBE;	**National Bank of Ethiopia**
OECD:	**Organization for Economic Co-Operation and Development**
UNPFA:	**United Nations Fund for Population Activities**
UNDP:	**United Nations Development Program**
UNEP:	**United Nations Environment Program**

Table of Content

s

Abstract

Since the introduction of climate resilient and green economy strategy, Ethiopia has developed a series of policies to meet sustainable development goals. A significant portion of climate finance (90%) in Ethiopia comes from grants and loans and the country only invests less than 2% of its GDP in climate-related expenditures. This study tried to model the implications of imposing taxes on pollution emissions on aggregate data and examine its effect on reducing pollution emissions, enhancing sustainable economic growth and social welfare using a more holistic approach in system dynamics. The findings showed that though imposing ecotax can have short-term negative effects, in the long run, it reduces pollution emissions, enhances sustainable growth, and maintains social welfare through improved per capita income.

Keywords: Inclusive Green growth, Ecotax, Sustainable Finance, Green Economy, System Dynamic

Chapter one

Introduction

1.1 Background of the study

One of the critical issues driving the sustainable development goals and agenda for 2030 is building an environmentally friendly economy. This requires minimizing the activities that harm the environment and these activities have been substantiated by the introduction of green tax as a way to raise revenue to achieve sustainable development goals. Environmental taxes play a vital role in attaining environmental effectiveness, and economic efficiency; they can be helping tools in raising public revenue and transparency. They also help in minimizing water pollution, waste disposal, and air emission.

Protagonists of green taxes contend that green taxes tend to correct the market failure by reducing the distortionary effects of other taxes and ensuring that the costs of externalities are institutionalized in the price of the product. On the other hand, increased pressure on environmental challenges, proper use of natural resources health issues arising from some energy sources, and environmental degradation have also necessitated the need for Ecotax (Cottrell et al. 2015). Pigou (1920), argued that taxes on carbon emission is the most productive approach to reducing and mitigating carbon emission and their impact on the environment. Though the economic and environmental outcome of Ecotax is dubious, it gives consumers and businesses the flexibility to determine how best to minimize the environmental issues. It pushes for low-cost solutions paves the way for innovation and minimizes the need for the government to attempt to "pick winners".

Taxes in general and Ecotax, in particular, require a well-designed policy that takes into account the tax burden and tax incidence on the consumers and it requires a multidimensional look into how this tax can affect and be integrated into the economic system. Ecotaxes are not like other tax categories; their design needs careful consideration of various factors. Their ultimate cost can extend to reduced environmental effects and higher economic costs.

Among other priorities, inclusive growth and sustainable finance have been drafted as the goal of agenda 2063, which requires social security protection, poverty, and inequality. It is also believed that climate change will adversely affect the African continent for many years to come and the 2007 inter-panel discussion on climate change has declared Africa as the most vulnerable continent to climate change and climate variability which has been exasperated by the link between multiple stresses at various levels and the continent's low adaptive capacity.

In response to Agenda 2063, Ethiopia introduced climate resilient green economy in 2011 and designed the strategy to be one of the middle-income countries by the year 2025 and build an economy resilient to climate change and no net increase in greenhouse gas emission by the year 2010(*Ethiopia's Climate Resilient Green Economy National Adaptation Plan Federal Democratic Republic of Ethiopia*, 2019). Building a climate-resilient economy can't come from out of the blue, it requires investment and sustainable finance and the government believes that this can be done through domestic funding putting the already stained financial resources under pressure. Among the mechanisms of funding targeted include, loans, grants, and equity. None of the instruments mentioned state the need for Ecotax. Unless the economy generates funds to build the intended economy there is less chance that we achieve what we aspire to as a nation only through foreign support. The government states the need for domestic savings which is just under 20% of the GDP, to be used as means of financing the climate-resilient economy

(*Ethiopia's Climate Resilient Green Economy National Adaptation Plan Federal Democratic Republic of Ethiopia*,). Among the many benefits, a well-structured Ecotax can have a significant effect on inclusive green growth and sustainable finance.

Economic growth is a means to achieve social goals which characterize development. growth has to reflect social equity and environmental sustainability to qualify for development. this will drive long-term growth by reducing poverty, expanding the middle class, creating employment opportunities, and increasing resilience to shocks. Inclusive green growth encompasses the three pillars of economic growth (sustaining strong growth and openness), social equity(supporting human capital development, social inclusion, and reducing inequality), and environmental sustainability (limiting environmental degradation and impacts of climate change). The IGG, therefore, is a better tool to assess the country's progress in achieving sustainable development goals there than the conventional GDP. IGG addresses the issue of SDGs better than GDP and most countries have calibrated their development goals in line with SDGs but the indicators for measuring the status of sustainable development goals have yet to be designed and may only be ready by the year 2025. The data used to address the IGG is taken from publicly available data which makes monitoring the SDGs relatively easy and transparent.

The quality of growth can also be tracked by the countries' response to corruption, inefficiency, and weak enforcement of the rule of law. the lack of effective and fair institutions exposes the country's institutional risk which intern reduced the quality of growth and ultimately the IGG (Jha et al., 2018).

In countries like France, ecotax is used among other things to reduce the impact of road freight transport on the environment and encourage other means of transport. the introduction of ecotax has raised nearly 1.2 billion euros per year and distributed for rebuilding infrastructure, levy

charges, and local authorities. This has contributed to an increase in government revenue and support expenditures. This by no means comes at free cost; it has strained the relationship between the transport industry and the public and also the forwarder. the passing-on effect requires the transport service providers to pass their costs to those who benefit from the transport which intern motivates other means of transport besides road fright (French Ecotax-pvt group, 2013).

As mentioned in Canis (2013) the united states government offers a $7500 tax credit to encourage the production of electric cars as a means to reduce carbon emissions. and to fulfill the Kyoto Protocol Norway has introduced the highest co2 tax in the world (Bruvoll 2002). the Ethiopian climate-resilient green economy is introduced with the same goal of fostering environmentally friendly technologies which will minimize emissions and at the same time contribute to economic growth by improving revenue.

The introduction of CRGE is to tackle the severity of climate change and its impact on weather-dependent agriculture which is highly exposed to the variability of climate change. and hence the government has shifted from a carbon-intensive approach to low a carbon, sustainable, and climate-resilient pathway. This approach is expected to reduce the per capita emission by 64% and ensure a resilient economic transformation to a carbon neutral country (the *Federal Democratic Republic Of Ethiopia Ministry of Environment, Forest and Climate Change National Redd+ Secretariat National Redd+ Strategy Acknowledgements*, 2018). It is also important to note that environmental taxes can affect low-income households, thus care must be taken in applying ecotax and ecotax rates.

There have not been many articles written about the context of green tax or ecotax in Ethiopia but there are some who have tried to examine environmental financing by taxing plastic products

Deslagen et al (2022). the study was primarily conducted to identify whether it is beneficiary to tax plastic products or to abandon them generally. And the findings suggested that taxing plastic products has a more productive role than banning them as it generates revenue for the government and creates more finance for environmental protection. It is also argued that taxing plastic products avoids unnecessary stress that comes with lost jobs as banning affects multiple sectors. The study also states challenges such as weak or unreliable collection systems, and limited organizational capacity as a limitation to affect the policy.

The issue of a green economy or green growth cannot be attained without the finances that support the cause. And the issue of sustainable finance to support the growing climate-related causes must be raised in parallel with the trending issue of green growth and sustainable development goals. The international community has played its part by raising international public policies directed toward providing financial support for developing countries. The Ethiopian green economic policy and the finances to assure a climate-resilient economy has been supported by these financial aids either through technical assistance, capacity building, or through direct interventions in climate adaptations and mitigation activities.

The main purpose of this study is to examine how the green tax (ecotax) can be used as a tool to support sustainable finances that can be used to promote green growth in Ethiopia and create a platform for an economy to develop its capacity to support the cause without being solely dependent on external finance.

1.2 Statement of Problem

There have been undeniable adverse effects of climate change globally which has caused damage to the social, economic, and physical environments in both developed and developing countries.

The rigorousness of the problem has been felt vastly by developing countries that can't tackle it. Case in point, the global cost of responding to climate-related damages has amounted to be 551million per year (UNFPA 2009), this cost is estimated to be $10 billion per year for developing countries and expected to rise to $435 to 840 billion per year in the year 2030(world bank 2010 as cited on Habtamu, 2015).

The impact of climate change has also been felt in the Ethiopian economy in the last decades including devastating droughts, crises in food security, and health impacts. It has also been evident in an increased temperature and decreasing rainfall specifically in the northern part of Ethiopia which is vulnerable to drought with an annual rainfall of 100mm (OECD 2013). These will ultimately cause damage to agriculture, deteriorate infrastructure and worsen the lively hood of the rural poor. Society is highly dependent on agriculture which requires proper land management to conserve watersheds and biodiversity and these will increase the threat of climate change including the risk of drought and more extreme weather. Therefore, there can only be a holistic approach to the problem if problems can be solved and synergies are realized (OECD 2013).

In line with climate resilient economy to promote green growth Ethiopia is the fifth most recipient of climate-related aid between 2010 and 2012 in Africa and the third most receiver of climate finance (USD 0.43 billion) in the yet and based on climate vulnerability index as reported on (UNDP,2023) Ethiopia ranks 19th in the world and 3rd in Africa in the list of countries at the risk of climate change. This risk will also be exasperated under a high emission scenario which will push mean monthly temperature by 1.8^{o}C by the year 2050 and by 3.7^{0}C by the end of the century. As reported in Ethiopia's Third National Communication to the United Nations between 1994 and 2018 due to various economic forces the Ethiopian emission

increased from 108333 Gg of CO2e to 368,835 Gg of CO2e showing an increase of 240% and in 2016 Ethiopia reported per-capita emission of 0.01 and 0.015 in 2020 showing an increase in the level of CO2 and the total of 10,438,855 tons of CO_2 in 2016. And the majority of the emission comes from agriculture, forestry, and land use followed by the energy sector (7%). This will require a different perspective in responding to climate policies and strategies and the introduction of ecotax will help in broadening the financial base and help sustainable finance to help the cause and this will only add to increased finance to green growth.

As Ethiopia aspires to achieve a climate-resilient green economy, the introduction of Ecotax is not an if but rather when. Due to the sensitivity of tax issues in general and Ecotax in particular and the need to see it in a holistic application, the research will apply the system dynamics model to examine the link, flow, and casual relationship between sectors and economic variables.

Accordingly, though there have been attempts to study climate change finance in Ethiopia and pollution (Habtamu 2015, Desalegn 2021) to name, the study couldn't find any published material on the application of system dynamics to examine the nexus between green growth, sustainable finance, and ecotax. To this end, the study will add to a much-needed response to climate change and the previous models designed by Block et (2013) have not been tested in the Ethiopian context. Therefore, it will add more dimensions to policymakers in addressing how environmental tax can be integrated into sustainable finance to derive economic growth.

1.3 Objectives of the Study

1.3.1 General objective

The general objective of the research is to model the relationship between inclusive green growth and Sustainable Finance through Ecotax using the System Dynamics model.

1.3.2 Specific Objectives of the Study:

Based on the above general objective the study tried to address the following specific objectives:

- To examine the relationship between Ecotax, sustainable finance, and economic growth.
- To examine the repercussion of Ecotax in enhancing environmental sustainability.
- To scrutinize the implication of environmental taxes on maintaining social equity.

1.4 Significance of the Study

As stated by Mankiw et al. (2016) mainstream economics has widely celebrated the role of green taxes in reducing pollution as an effective tool to internalize the negative externalities of economic development. this has created an awareness of the producers to assume green taxes as costs which intern plays a role in minimizing it. The fundamental role of ecotax is to minimize the environmental damage arising from polluting operations. This study will have major implications for green growth as it plays hand in hand with sustainable finance to achieve it. The study result will have a paramount implication on directing the ways environmental protections are financed as it examines the “polluter pays” approach.

From the economic point of view, it will support the government's view on green growth and might play into the government's hand to exercise some environment-related taxes or reform the excises tax to work better the Ethiopian climate-resilient green economy that has been introduced into the Ethiopian government economic policy. If there is a way to create a climate-friendly economy by reducing carbon emissions, then Ecotax does just that. It will support the government's fiscal policy by generating revenues that could be used to finance the emission and support those parts of the community that may be affected by the changes in price as a result of the emission-related tax.

The research result will also direct the government's fiscal policy and will suggest how the revenue that is generated from ecotax can be recycled to support the economy and will also show the cost and befits of environmental taxes. The methodological approach that will be used in this research will give a holistic view of imposing ecotax on the overall economic performance of the country and will substantiate the Ethiopian climate resilient economy strategy.

1.5 Scope of the Study

This study is primarily based on the national level data on environmental protection and the activities that are designed to support it. It took into account the current tax regime that the government levies on environmentally damaging products such as excise taxes and also tried to look into alternative policies to support a climate-resilient economy. The study focused on the data after the introduction of the green growth policy by OECD 2010 to see the government's response to global issues. the variables used in the model are generated from past studies and customized to make sense of the Ethiopian economy and most of the arguments about the variables came from two pioneer studies by Block et al (2011 and 2013) on inclusive growth and sustainable finance.

1.6 Structure of the Thesis

This study is organized into four chapters, the first chapter deals with the introductory parts and the rationale behind raising the topic for discussion. Chapter two covers both the theoretical and empirical evidence surrounding green growth, ecotax, and the system dynamics model. Chapter three covers the methodological designs and approaches used to address the research questions. Chapter four will focus on the data analysis, simulations, and discussion of the results, and policy implications, and the last chapter will address the major findings, the conclusion, and the recommendations of the study.

Chapter Two

Review of Related Literature

This chapter reviews the theoretical and empirical evidence surrounding green growth, sustainable finance, ecotax, and the theoretical empirical underpinning of using system dynamics to link each of the elements.

2. Theoretical Reviews

2.1 Green growth

Green growth implies fostering economic growth and development while maintaining natural resources which creates a conducive environment for our well-being. this requires collaboration between investment and innovation which will enhance sustainable growth and create economic opportunities. development, in general, requires expansion and consumes extensive capital, and erodes natural resources which ultimately results in scarcity of resources like water and threatens climate change, and causes irreversible biodiversity loss(*OECD, 2011*).

green growth opens the doors for a new way of thinking and growth approach by enhancing productivity by promoting operational efficiency, reducing waste, and directing resources toward their most efficient use. it also plays a significant role in innovation by designing policies and frameworks which allow new ways of thinking and operation which address environmentally friendly activities. it also creates a new market for green technologies, products, and services, and it creates new job opportunities.

The African Development Bank (2012) defines green growth as the selection of activities that promote environmental and social developments and protect the environment and human welfare. it also necessitates the quality of growth should go hand in hand with the careful

delivery of safe social and environmental consequences. others such as the United Nations, and World Bank define green growth as economic development and job creation arising from the reduction of emissions and improvements in the efficiency of natural resources as a result (African development bank 2012).

Green growth is not size fit all policy, every country needs to find its strategy to go greener and it requires the government's involvement and political commitment also it needs the ministries at various hierarchies to act accordingly. The policy demands the participation of the private sector and the public-private partnership. The green growth initiative and constraints are given in the table below:

Table 1 green growth policy and Constraints according to OECD (2011)

Green growth constraints	**Policy options**
Inadequate infrastructure	Public investment, public-private partnership, Tariffs, and Transfers
Low human and social capital and poor institutional quality	Subsidy reform/removal Growing and stabilizing government revenue
Incomplete property rights and subsidy	Review and reform or remove
Regulatory uncertainty	Set targets, create an independent government system
Environmental externalities	Tradable permits, subsidies, and taxes
Information externalities and split incentives	Labeling, technology and performance standards, subsidies
Network effects	Strengthen competition in network industries, Subsidies or loan guarantees for new network projects
Barriers to competition	Reform regulation, reduce government monopoly

The OECD green growth framework suggests four indicators to track the progress of green growth which is based on previous work and experience. These indicators are given below in Table 2 : Indicators of Green Growth

1	Ecological and resource yield of the economy	- Carbon and energy efficiency - Resource efficiency, material, water, and nutrients - multi factor productivity
2	The inherent wealth of natural resource	Renewable resource reserves encompass water, forests, and fish stocks. Nonrenewable resources include mineral deposits. Biodiversity and ecosystems contribute to the natural asset base.
3	The ecological aspect of quality of li	environmental well-being and potential hazards Ecosystem functions and benefits
4	Opportunities for economic growth and governmental measure	Advancements in technology and creative solutions Goods and services related to the environment Global financial regulations Pricing and transactions Training for acquiring skills Approach to regulations and management

It has been discussed in various literatures that GDP fails to capture some fundamental aspects of sustainable growth. And some mechanisms can be used to make it a more comprehensive measure of development.

2.2 Ecotax (Green Tax, Environmental tax)

Though there are multiple views and definitions regarding ecotax, most views are focused on four basic aspects. Tax base, earmarking the revenue from the tax. Tax type i.e. ad-valorem or per unit tax and whether the tax received is requited or unrequited payment. To this end, Steinbach et al. (2009) define ecotax as any compulsory unrequited payment levied on a tax base that has particular environmental relevance. the unrequited aspect of tax implies the benefits provided to taxpayers are not in proportion to their payment. In a more general context Eurostat (2009), defined ecotax as a tax whose tax base is a physical unit that has proven a negative impact on the environment.

Eurostat (2001: 12, cited in Steinbach, et al. 2009: 4) discusses that environmental taxes are classified in the literature into four basic parts: energy, transport, pollution, and resource taxes. Milen and Andersen (2012) suggest other categorizations such as emission and effluent tax, product tax, and natural resource taxes due to some limitations in the previous classification. For instance, CO_2 are considered an energy tax as they are difficult to segregate the taxes from energy. The literature suggests that taxes on mineral oil are due to high carbon content. But the latter classification would separate carbon taxes as emission and effluent taxes when emissions are charged separately and under product taxes, minerals with carbon content can be taxed which will avoid any ambiguity.

OECD (2011) stresses that environmental taxes can be levied to address market failures to consider environmental impacts by incorporating them into prices and also it leaves consumers

and businesses the flexibility to determine how best to determine the environmental "footprints". The report also suggests that without government intervention firms don't have market incentives to take care of environmental damages as it impacts various parts of the community and the economy at large, it has very little effect or direct cost on the polluter. The command and control tools used in the past such as banning and limiting certain a particular product or substance or requiring industries to use certain technologies has been ineffective.

2.3 Environmental tax incentives

OECD's (2011) report also suggests that the government can use tax incentives as a mechanism for reducing environmental damages rather than imposing environmental taxes. One way to achieve this is through Value added tax exemptions for energy-efficient technologies or favorable depreciation rates for capital investments in renewable energy or pollution abatement.

2.3.1 Designing effective Ecotax

For green taxes to work, it requires careful consideration of several factors. A poorly designed environmental tax may adversely affect the environment and might cause high economic damage**.**

2.3.2 Defining the Tax Base

Ecotax should target the pollutant or the polluting behavior and increasing the market cost of the polluting activity helps to maximize the full range of abatement options such as efficient and clean production process and adoption of products with a less environmental cost. A close proxy for polluting activity can provide a good tax base. It is difficult to tax the emission from vehicles directly due to the administrative costs involved. Due to carbon emission being highly correlated to fuel consumption, it would rather be feasible to levy a tax on the fuel to tax CO_2 emission

these taxes can be collected at wholesale or refinery. Other emissions might be difficult to entertain the same approach at a higher supply chain. It is also important that the tax rates that are used for emission should not create any misspecification. There is no size-fit policy, living a carbon tax per liter on both gasoline and diesel might reduce the efficacy of carbon tax as it might favor dirtier fuel.

2.3.3 The Scope of environmental tax

It is important to match the scope of the environmental tax to the extent of environmental damage being addressed. Issues like soil contamination will require political jurisdiction as they can be handled easily at the state or municipality level. This however is not the case in environmental taxes since greenhouse gas has more of a global basis and requires global tax. Other issues related to water and air pollution can occur in a certain area and their effect can be felt in other jurisdictions.

2.3.4 Broad Tax Base

The uniformity of the tax base is mandatory as homogeneous taxes encourage abatement at the lowest cost source to support environmental goals achieved. Uniform taxes also reduce compliance costs for taxpayers and the cost of administration for the government and reduce the opportunities for tax evasion. However it is also important to consider the impact of these taxes on low-income households, and pollution-intensive, trade-exposed businesses. applying lower taxes rates and exemptions can reduce the incentives provided by the tax to some of these groups but not for all. There the government should attempt to implement ecotax as broadly as possible with few or no exemptions(*Environmental Taxation A Guide for Policy Makers*, OECD 2011).

it is also important to note that taxes like excise taxes, registration fees, and annual road taxes are weak to capture taxes from co2 emissions from motor fuels due to the size of their engine and the

miles are driven. a similar issue with the tax base is the tax rate and it is important to note that all emissions should be priced but they should also be priced at the same rate according to the Pigoun framework (1920) that is pollution content should be charged at the same rate across fuels and across end users.

2.3.5 Using the revenue generated

There is no significant revenue generated from environmental taxes as most taxes bases are limited to co2 and taxes on driving such as fuel, vehicles, and tolls. In OECD countries they approximately contributed 5% of total tax revenue. Contrary to other taxes these taxes try to minimize the tax base while other taxes try to raise revenue at least cost to the tax base. The revenue collected from environmental taxes will make up part of the general revenue which could be used to maintain spending in other areas, reduce debt, or reduce taxes. The theories suggest that this revenue can be used to support those who are most affected by the pollution, however, it is practically difficult to measure the extent of damage to individuals, and many environmental issues have intergenerational effects. It is important to note that earmarking the revenues from environmental taxes to support public spending can increase the political acceptability of ecotax.

2.4 Principles of Environmental tax design

According to the Pigouvian framework (Pigou 1920), the environmental tax should equal the marginal damages and be imposed on the source of emission. The framework didn't state the issue regarding revenue recycling. In the Pigouvan framework of corrective tax, the tax equals the marginal damages which induce emission reduction, and the marginal benefits of or avoided environmental damages equal marginal abatement cost.

2.4.1 Externality measurement

The quantitative value of local pollution damage and its monetary value has been difficult to measure even in countries where a high level of the model is involved. on the other hand, the level of damage varies across space and the exposure of the local population and natural factors affect its dispersion (Heine et al., 2012).

The extent of externalities is diverse and endemic in various sectors. Fuel combustion, for instance, causes a variety of local pollutants in addition to co2, and the need for legislation to address these pollutants needs to be in place. There is no single charge that can address the variety of pollutants rather it is the combination of the charges which will address most. some externalities in the transport sector are exceptions as it depends on the vehicle mileage and fuel economy whereas others might only change with mileage(Heine et al., 2012).

Distribution and Competitiveness

One of the typical characteristics of a tax system is distributional justice; however environmental taxes might undermine this trait specifically in developing countries where lower-income households have most of their income taken by energy foods (Metcalf, 2009). Environmental taxes might also have negative consequences on the competitiveness of energy-intensive firms as it imposes higher taxes which intern drives higher prices such as the aluminum, cement, and steel industries as a result they lose their share in the global market. As Oates (2002) discusses, the harmonization of environmental taxes across countries will elevate the problem in the case of global pollutants like Co2, the issue will be different when marginal damages vary by country.

2.5 Inclusive Green Growth

The era of quantitative measures of economic growth has been replaced since the 2015 by global agreement on sustainable development goals and climate change marked as the international

discourse on development shifted from quantity of growth to quality of growth. Better growth would mean increased income, reduced poverty, improved health services, livable cities, and improved climate change by reducing greenhouse gas(Jha et al., 2018).

The three pillars of inclusive green growth include; economic growth, environmental sustainability, and social equity. The framework requires economic growth to be measured using GDP, trade openness, age dependency ratio, and government debt. Social equity could be measured with several variables such as employment to population, labor share, life expectancy, access to water, and electricity. Environmental sustainability can be addressed using emissions to GDP, air pollution, and energy intensity. There are no specific rules as to what measurement tools fit all rather countries have their choices to make based on the available data.

Fig 2.1 Inclusive green growth pillars

2.5.1 Balancing the Three Pillars

Striking a harmonious equilibrium among the pillars leads to more effective policy decisions aimed at enhancing the quality of economic growth. This approach aligns with global development objectives, including the Sustainable Development Goals (SDGs) and the Paris climate change agreement, while also promoting economic grow. Given the interconnected

nature of IGGI indicators, achieving these objectives require integrated approaches to development by recognizing that a change to one part of a complex economic, technological, and socio-ecological system can lead to changes in other parts. Fossil fuel subsidies are a good example of the usefulness of an integrated systems approach since they encompass the environment, energy, and economic and social dimensions of growth. These subsidies are widely used in Asia to encourage energy production and to provide cheap energy to the poor. But they dig into priority development spending and benefit mainly the better-off who drive gas-guzzling cars and live in air-conditioned homes. Artificially low prices also discourage investments in renewable energy and lead to increased greenhouse gas emissions from higher demand for coal, oil, and gas. To successfully eliminate these subsidies, coordination is needed across stakeholders(Jha et al., 2018).

2.6 Fiscal sustainability

Over the past decade, ensuring fiscal sustainability has emerged as a crucial objective. It serves the dual purpose of maintaining macroeconomic stability and effectively allocating public resources for the provision of essential services. However, achieving fiscal stability is a complex task due to the influence of various social, economic, and environmental factors on public revenues and expenditure.

Government revenues are influenced by multiple factors, including the implementation of environmental taxes, personal income taxes, consumption taxes, and corporate profit taxes. On the other hand, government expenditures are impacted by investments in energy supply, energy imports, potential energy subsidies, and the environmental consequences associated with fossil fuel usage, such as carbon emission.

The dynamics between government budget and revenue streams reveal reinforcing and balancing loops. While challenges tend to become more difficult to resolve due to reinforcing loops, government revenues are mostly affected by balancing loops. This means that as the economy grows and investments are made in greener initiatives like energy efficiency, the revenue generated from environmental taxation decreases. However, traditional macroeconomic feedback loops, where investment leads to economic growth, counterbalance these effects. These are positive reinforcing loops, which counter, and historically have dominated, the reinforcing and balancing loops mentioned abo (Andrea M. Bassi, 2020).

2.7 Ethiopia's National Setting

According to the M Ethiopia is 8th in Africa and 25th in the world in terms of area which counts for 1.13 million km2 coupled with complete topography of high mountains, plateaus valleys, and gorgeous extending from the highlands. Ethiopia follows a federal system with 11 autonomous regional states and two chartered city administrations.

2.7.1 Climate, Agro ecology, and land Use

Ethiopia's rainfall distribution is determined by inter tropical convergence zone with two rainy seasons of Keremt and Belg. Keremet accounts for nearly 50 to 80 % of total annual rainfall. Ethiopia is most vulnerable to climate change due to its agriculture-dependent economy and which again faces serious damages with temperature growing by a magnitude of 0.2 to 0.28 o in the last six decades. by the year 2050, it is expected to increase from 0.5 to 2 The country's land use is dominated by agriculture/cultivated land, forest, grazing land wetlands, and settlements.

2.7.2 Demography and social profile

Following Nigeria, Ethiopia is the second most populous country in Africa. the 2018 report shows a population of 110 million which is expected to reach 136 by the year 2037. 22.8% of the population lives in urban centers with expected growth of 31,1% in 2017. Compared to sub-Saharan countries the country registered a higher annual urbanization rate of 4.5%. Ethiopia has made significant progress in education with annual primary enrollment of 85 % in 2014 to 109.5% in 2017. In 2016 the average year of education for adults aged 15 years and above was 3.8 years, 4.4 for males, and 3.2 for females.

Concerning health, over the last two decades, the GoE has established 16,440 health posts and 3,547 health centers and has built 311 hospitals. this has increased life expectancy by 40% and reduced infant mortality by 60% in the last decades. According to the 2016 DHS, about 65% of the households in Ethiopia have access to improved sources of drinking water. Access to improved sanitation increased by 19% from 2000 to 2015. Despite that progress, Ethiopia ranks 32nd among 54 African countries and 162nd in the world in terms of the percentage of its population with access to improved sanitation facilities (MOP 2022).

2.7.3 Economic Profile and Infrastructure

MOP (2022) Ethiopia has experienced remarkable economic growth and significant poverty reduction over the past twenty years. The country's real GDP has shown substantial growth, increasing from $8.24 billion in 2000 to $29.93 billion in 2010 and reaching $84.3 billion in 2018. The average GDP growth between 2001 and 2010 was 8.74%, while it averaged 9.73% between 2011 and 2018. In terms of sectoral contributions, the service sector has consistently accounted for the largest proportion of the economy's GDP (40%), followed by agriculture (37%), and industry (23%)

Within the agricultural sector, crop production represents the majority, contributing 65%, while animal farming and hunting, as well as forestry, contribute 8.6% each. Crop production increased by 5.7%, while animal farming and hunting, and forestry saw respective increases of 5.8% and 3.9%. Manufacturing is the primary industry sector, accounting for 23.4% of total industrial production. The construction industry expanded by 6.6%, with significant contributions from road, railway, dam, and residential constructions.

Ethiopia's strong economic growth has led to notable social advancements across various sectors, including a significant reduction in poverty. This decline in poverty is attributed to both economic growth and the implementation of social protection programs, such as the Productive Safety Net Programme (PSNP) and urban food distribution and subsidies. In 2016, government expenditure accounted for 16% of GDP, while revenues represented close to 22% of GDP, both lower than the rates observed in other low-income African countries.

Agriculture plays a vital role in Ethiopia's economy, generating the largest share of export earnings. Despite having substantial cultivable land, the total cultivated area for crop production is 12.9 million hectares, with cereals occupying 81.5% of the land, pulses occupying 12.2%, and oilseeds occupying 6.4%. The total grain production reached 335.2 million quintals, with cereals accounting for 88.5% and pulses and oilseeds comprising 11.5%. Crop production contributes 32.7% to the agricultural GDP. Ethiopia boasts the largest livestock population in Africa, including 60 million cattle, 31.3 million sheep, 32.7 million goats, 1.4 million camels, and 56.9 million poultry.

However, industrial development in Ethiopia remains relatively low. The manufacturing sector is small compared to other African countries, with mixed success in various light manufacturing

sectors. Manufacturing growth has struggled to keep pace with the country's overall economic growth and GDP

Ethiopia's export structure is characterized by a concentration on a few key commodities, such as coffee, oil seeds, pulses, and Khat. Coffee alone accounts for 29.5% of the country's total merchandise export earnings. Service exports have been driven by the growth of Ethiopian Airlines. Public investments in capital and construction equipment have contributed to a persistent trade deficit, ranging between 16% and 22% over the past decade. In 2018, the trade deficit stood at approximately 18% of GDP, higher than the average for low-income African countries and significantly higher than its regional counterparts. Transport services play a crucial role in the implementation of national development plan.

2.7.4 Waste Management

Despite Ethiopia's ratification of various waste management conventions such as Basel, Stockholm, and Rotterdam, and the implementation of policies and legislation to address waste issues, there is a notable deficiency in effectively managing environmentally hazardous chemicals and waste. The enforcement of existing waste management regulations is lacking, resulting in inadequate implementation. The generation of waste is directly correlated with population growth and urbanization trends. With the population and number of urban residents continuously increasing, waste generation has risen from 9,700 tons per day in 2015 to 12,200 tons per day in 2020. It is projected that by 2030, the national waste generation rate will double that of 2015, reaching 24,400 tons per day.

Ethiopia is the sixth largest and fast-growing economy in Africa and has the aspiration to become a middle-income country by the year 2025. however economic growth alone is not good enough to achieve sustainable development goals, it requires an economy that responds to the

environment and inequality. in line with this Ethiopia introduced Climate Resilient Green Economy (CRGE) strategy in 2011. this policy is designed to make economic growth respond to climate changes which targets low-carbon energy developments, conservation of forest reserves, and engaging in climate-smart agriculture with a special focus on adaptation and resilience(Padmanabhi et al, 2022). According to a world bank report (2020), Ethiopia has reported 9.5% growth in the last 15 years claiming one of the fastest-growing economies in the world.

Though the economy is growing fast, Ethiopia's contribution to greenhouse gas emissions is the lowest with 0.04% in 2019, however, this has not reduced Ethiopian vulnerability to climate change. Drought and desertification have been recurring traits of the Ethiopian economy registering with annual warming expected to reach 1.5 to 3^0 in the year 2050. In 2022, Ethiopia registered its worst drought in forty years nearly endangering 7 million lives and with expected damages to cost 10% of GDP coming from damages to agriculture productivity by the year 2045(USAID 2016).

2.7.5 National Green House Gas Inventory

Between 1994 and 2018 emissions from economic sectors have grown due to the rising economic growth. The total national emission has increased from 108333 ggs of co2 e to 368835 ggs, showing an increase of 240%. The majority of the emission comes from AFOLU sector followed by energy(7%). the GHG from the forest has been removed or shown significant reduction due to afforestation and reforestation efforts by the government.

2.7.6 Energy sector

The energy sector is the most deriving force of the country's economy and Ethiopia has a significant source of renewable energy. The potential energy for hydropower is estimated at

45000mw, of which only 5 have been exploited. As noted by Tiruye (2021) Ethiopia has the potential to generate 10000mw of solar energy and around 5000mw of geothermal energy. Despite this enormous potential, not more than 5% of the energy from hydropower has been used. The traditional biomass fuels, which made up around 87% of the country's total primary energy use, include charcoal, fuel wood, dung cakes, and agricultural waste (Tiruye, 2021). Ethiopia intends to generate foreign exchange by utilizing all of its potential for producing electricity, mostly from hydropower plants. The enormous amount of electricity generation hydropower like the Ethiopian Renaissance Dam will also contribute to the region's economic integrity.

2.7.7 Agriculture, Forestry, and Other Land Use (AFOLU)

The AFOLU sector activities account for a significant portion of Ethiopia's greenhouse gas (GHG) emissions. In 2018, the country's total CO2e emissions reached 334,579.8 Gg. On the positive side, the AFOLU sector played a crucial role in removing 108,422 Gg of CO2e during the same year. Consequently, the net GHG emissions for the AFOLU sector in 2018 amounted to 226,157 Gg of CO2e. The main contributor to overall emissions was CO2 from land-related activities, followed by enteric fermentation CH4 emissions from the livestock subcategory. Analyzing the gas emission data, CO2 accounted for a total of 231,830.5 Gg of CO2e, CH4 accounted for 96,144.01 Gg of CO2e, and N2O accounted for 96,144.01 Gg of CO2e. Over time, the emission trend within this sector shows a notable increase in net emissions, rising from 19,586.06 Gg of CO2e in 1994 to 226,157.6 Gg of co2e..

2.8 System Dynamics

According to Gordon (1978), a system refers to an aggregation of interconnected elements governed by predefined rules. System dynamics (SD) is an approach used for modeling and

describing the behavior of complex systems over time. Unlike other modeling approaches, SD employs feedback loops, stocks, and flows to capture the dynamic nonlinearity of systems.

Forrester (1968) defined system dynamics as a modeling approach specifically aimed at studying feedback behavior in management information systems. It utilizes models to design system structures and support decision-making in complex and dynamic systems. Initially applied to business management, SD gained prominence through the book "Limits to Growth" (Meadows et al., 1972), which simulated future scenarios of a resource-limited world with unchecked economic growth.

Sterman (1989) introduced the well-known Beer Game, a simulation that depicts the behavior of supply chains, including the bullwhip effect and safety stocks. In management and social systems, system dynamics models have been employed by researchers and policymakers to conduct policy experiments (Mohapatra et al., 1994). Additionally, system dynamics finds application in analyzing and evaluating environmental impacts, such as global warming and greenhouse gas emissions (Nail et al., 1992; Vrat et al., 1993; Anand et al., 2005).

The advantages and applications of system dynamics, as defined by Sterman (2000), encompass modeling high-level nonlinear systems with intricate feedback, revealing the relationship between internal and external factors, controlling various system factors, and observing system behavior and responses to trends. SD models can be constructed at an abstract level with limited data. The causal feedback loop diagram serves as the foundation for SD modeling, allowing users to analyze system variables, positive and negative feedback structures, causality, and time lag effects in complex problem-solving. This diagram enables the definition of key concepts, including the system boundary (main variables), causal relationships and directions among variables, and the fundamental structure or major feedback loop of the system.

The figure below provides an illustration of a positive causal link between two interconnected variables. The combination of multiple links forms a causal loop, and when the loop is closed, it becomes a causal feedback or closed loop. Positive feedback loops are characterized by continuous growth over time, indicating divergence in the mathematical model.

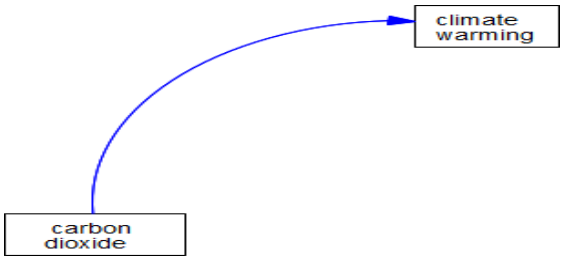


Fig 2.2 Positive Causal Link

After defining a causal feedback loop diagram, the system is modeled using simulation software. Common software applications for System Dynamics include STELLA, Vensim, Powersim, and iThink. These applications provide four basic objects which are the stock, flow, connector, and auxiliary. The stock represents the state of the system variables at a given time. The value of a stock depends on the inflow and outflow of a substance such as water flowing from a water tank. A flow represents the change of stock per unit of time. Stock values may be determined by interactions with other stock variables and auxiliary variables. A connector (arrow) is used to link stocks, flows, and auxiliary variables. Auxiliary variables are values of input parameters.

2.9 Empirical Evidence

2.9.1 International Studies

Block (2013) discussed the recent debt crises in the euro zone and the United States have sparked contentious debates regarding the relationship between socioeconomic factors. Kumhof and

Rancière (2010) proposed a model that explores the connection between the increasing income advantage enjoyed by high-income households, higher debt leverage among poor and middle-income households, and vulnerability to financial crises. On the other hand, Bordo and Meissner (2012) used panel data from 14 countries spanning over 120 years and found no significant evidence supporting rising income concentration as a determinant of credit booms. They developed a system dynamics model to analyze the relationship between economic growth, consumer debt, and distributional polit. understanding stock-and-flow dynamics is crucial in comprehending and addressing debt crises. In comparison to austerity measures, achieving income equality appears to be a more effective approach to tackle the challenges posed by debt crises. Inclusive growth is considered a prerequisite for sustainable finance.

Fan Xi et al (2019) stated that With green development becoming a global movement, environmental tax has been adopted by many governments to promote green development. Their study analyzes the impact of an environmental tax on green development by using a four-dimension dynamical system. The establishment of the system is based on the complex and dynamic interactions among economic development, pollution emissions, resource consumption, and environmental tax, where the roles of environmental tax are reflected by the linear parameters. A theoretic analysis shows the complexity of the behavior of the system. Mainly, the existence of chaos is inferred by the Lyapunov exponent spectrum and bifurcation diagram, then verified by the presence of a chaotic attractor.

An empirical study of the green development dynamical system in China demonstrates the particular evolution paths of economic growth, pollution intensity, and resource intensity under different environmental tax parameters. Results indicate a robust beneficial role of an environmental tax on green development. Furthermore, when an environmental tax is imposed,

firm government control, active consumer awareness, and an advanced technology level can stimulate economic growth, decrease pollution intensity, and control resource intensity. But government control has a stronger effect. This study provides a viable and promising approach to analyze the role of imposing an environmental tax on green development and may have potential application in other areas and countries.

Verma (2016) compared different forms of ecotaxes implemented in India and China to address carbon emissions and other environmental issues. The study provided a comprehensive definition of ecotaxes and analyzed their implementation status in the two countries. It highlighted governance-related challenges in managing funds generated from ecotaxes in India, while in China, the consumption tax was found to increase total fuel consumption and decrease social welfare.

Jiuli Yin et al (2019) tried to analyze the impact of an environmental tax on green development using a non-linear dynamic analysis using four dimensions among economic development, pollution emissions, resources consumption, and environmental tax, where the roles of environmental tax are reflected by the linear parameters. their finding indicated a significant contribution of an environmental tax on green development. They have strongly recommended that introducing a firm government control will enhance green growth in addition to customer awareness and advancement in technology.

Guo et al. (2016) employed a system dynamics approach to analyze the pathway toward green growth in Chinese industrial regions. Their study focused on the Liaoning province and investigated the relationship between green GDP, energy consumption, and CO2 emissions. The results indicated that a comprehensive optimization path scenario was the most effective in achieving green growth.

Li M. et (2021), wrote an article on the evaluation and research on the level of inclusive green growth in the Asia Pacific region. using four-dimensional analyses of economic prosperity, social inclusion, resource utilization, and environmental sustainability. the study used factor analysis supplemented by the clustering method and entropy method to evaluate and cross-validate the inclusive green growth level of 37 countries and regions in the Asia Pacific region. The study finding showed that the level of inclusive green growth is highly affected b the country's economic development. The paper summarizes the policy suggestions to promote inclusive green growth in the Asia-Pacific region, involving accelerating economic development and institutional improvement and reinforcing regional cooperation in the Asia-Pacific area for elevating the overall regional inclusive green transformation.

Musango K. et al. (2014) developed a model to analyze the transition to a green economy in South Africa. The study examined the contributions of technology policies to green economy transitions and highlighted the positive impacts of green economy interventions on sustainable resource utilization and resilient economic growth.

Gupta M et al. (2019) tried to measure the effectiveness of carbon tax on Indian road passengers' transport using a system dynamics approach. Their main objective was to examine where the carbon tax as a mitigation instrument could be effective in reducing co2 emissions from road passenger transport in India. Using simulation to draw various scenarios on the carbon tax on fuel based on the 2000 to 2011 major variables. The findings showed that using different tax rates has reduced co2 emissions in the range of 26 to 40% as compared to a baseline scenario in 2050.

Yuzhu (2010) examined the implication of green tax measures in addressing environmental problems in Hongkong using primary data through interviews and tries to make comparisons

among other countries. The findings suggested mechanisms to tackle pollution from various sectors. These include restricting the number of motor vehicles, imposing excise taxes on motor fuel, and providing tax incentives to encourage energy-efficient vehicles. they also introduced a sewage charging system to reduce water pollution and to reduce waste they have introduced a plastic bag tax.

2.9.2 Empirical Evidence in Ethiopia

The context of studies on green taxes in Ethiopia has been limited; Desalegn et al (2021) studied greening through taxation: the potential challenges and opportunities of plastic products in Ethiopia. His study was primarily qualitative study based on interviews based on the opinions and ideas of respondents. The findings suggested that having a tax on plastic products could provide more opportunities for the country than banning them. More specifically, taxing plastic products will be more appropriate for the generation of revenue employment, industrial process, construction process, and recycling in Ethiopia. On the other hand, a lack of proper collection systems, separation of the source of disposal, a properly designed operating system, clear authorities and sanitation rules, organizational capacity, and unreliable collection services were found to existing challenges of plastic products.

Habtamu (2015) on the other hand studied climate change finance in Ethiopia to gain an understanding of climate-related aid and policy frameworks which are defining the delivery of climate finance in Ethiopia. The study findings showed that even though there has been inspiring progress in the development of climate policy frameworks, funding mechanisms, and institutional arrangements, the actual implementation of the policy and functionality of the institutional arrangements has been trapped by many challenges that affect the effective delivery of climate change finance to the implementing and executing entities in the country. The study

also identified that the effective delivery of climate change finance to the implementing/executing entities at local levels is challenged by various issues/impediments including inadequate capacity, lack of shared understanding about the climate change policy framework, and weak coordination across sectors and actors at all levels, reflecting many unfinished duties remaining to realize effective delivery of climate finance to end users.

Birtukan (2020) tried to examine the need for an environmental pollution tax in Ethiopia using qualitative research based on interviews and desk reviews. her finding showed a lack of specific tax levied on the environment and she also tried to recommend activities that require the application of environmental tax to support climate finance in Ethiopia. though excise tax and customs duties play partial roles in protecting the environment, the tax laws specific to pollution such as water, air, and soil are non-existent and this has failed to discourage pollutants and resulted in lost revenue for the government.

Lalu (2013) also studied the environmental taxation practice and revenue performance in Ethiopia using surveys, structured interviews, and document analysis. the result of the study showed that there is no explicit environmental tax in Ethiopia but he claimed that there is an environmental tax base that categorizes the taxes as environmental taxes. the result also suggests the role of environmental taxes and the taxes can be used as a funding source for the government. he concluded by suggesting that the government should introduce guiding principles and manuals and enforce strict implementation.

In 2018, Geregiorgis examined the administrative feasibility of the environmental tax system in Ethiopia focusing on addis ababa city administration, and reaffirmed the findings of other researchers. he claimed that lack of effective collection systems to direct emission tax, the municipal waste disposal systems are less environmentally friendly. and concluded that solid

waste; landfill and sewer taxes are administratively feasible in Ethiopia, but effluent and emission taxes are not(Gebregiorgs, 2018).

Gebregiorgis (2018) added another research on the instrumental role of the introduction of the environmental tax in the realization of the polluter pays principle in Ethiopia based on single country case-oriented comparative research design and data triangulation. the finding revealed the application of the polluter pays principle, it also showed the degradation, redistribution, and preventive role of the polluter pays principle. it suggests that polluter pays principles restore water resource degradation, carbon taxes restore air degradation and royalties encourage reasonable use of scarce resources(Gebregiorgis, 2018).

2.10 Knowledge Gap

As has been discussed in the above literature coverage, little is known about the ecotax in Ethiopia dn most importantly there isn't any tax law designed specifically for environmental tax. The tax base to levy environmental tax has been discussed in the above research works and also the administrative issues related to environmental tax have been raised by Gebregiorgis. As for the researcher's assessment, there has not been an attempt to see the overall implication of employing ecotax on economic growth and environmental sustainability without jeopardizing social equity. Therefore, this research tries to address two basic limitations of past studies; first, it introduces ecotax to examine how it can reduce pollution emissions and enhance economic growth by sustaining income equality. Second, it tried to connect the sustainable development goals with the pillars of inclusive green growth such as economic growth, social equity, and environmental sustainability through internally generated funds from ecotax.

2.11 Conceptual Framework

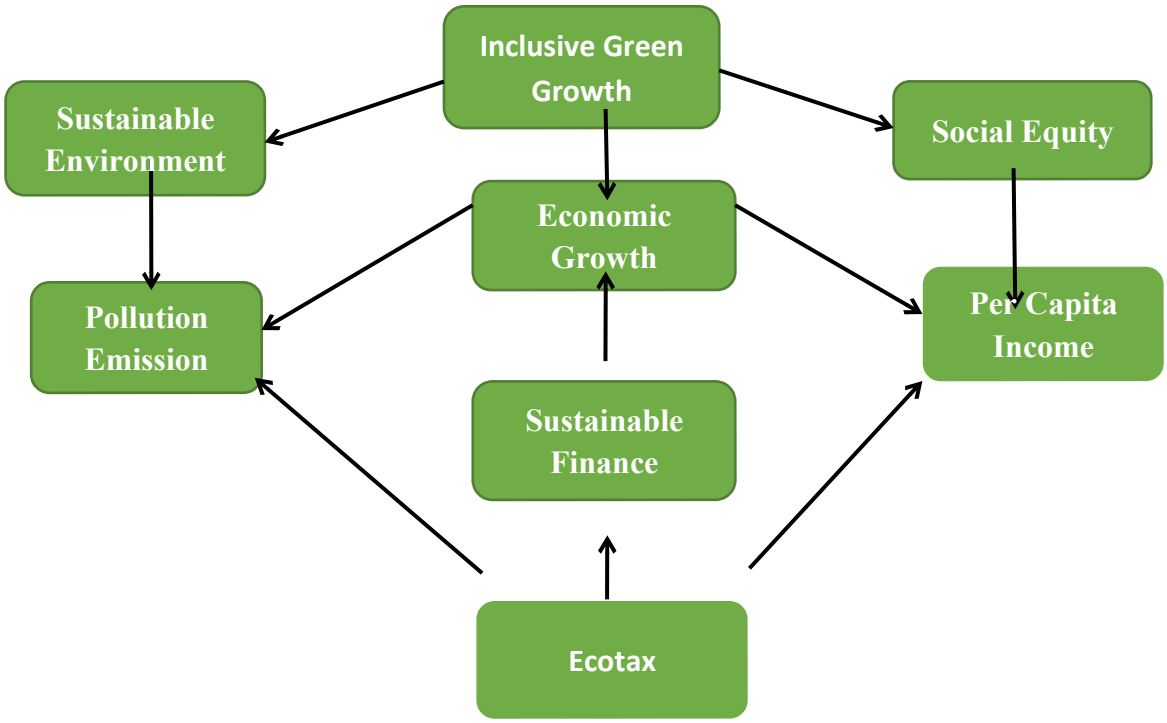


Fig 2.3 Conceptual Framework: Authors' Design Based on Literature

Chapter Three

3.1 Research Methodology

System dynamics focuses on conceptualization, formulation, and simulation and it follows a mixed design and addresses both qualitative and quantitative methods. At first, the model identifies system descriptions for problem development and frames qualitative analysis. It also prompts the knowledge of people to understand the context of the problem or build stories based on real scenarios. Subsequently, the conceptualization will be simulated to develop a quantitative argument. The research topic requires a comprehensive view of economic growth, inclusive growth, and sustainable finance which is used to address the nexus between economic growth, environmental sustainability, and social equity through the introduction of ecotax.

As with most taxes, Ecotax can involve a multitude of political and economic challenges, it can impose a burden on low-income households. Therefore, this study applies a more inclusive system dynamics model in addition to the previous model (block 2013) which focused on the relationships and forces between gross domestic product, consumer debt, and income inequality within the national economy. The current model used in this study has been customized to create more familiarity with the Ethiopian economy and address the research objective based on the available data.

The study heavily applied Desk reviews to understand the context of the problem from the data obtained from UNDP, NBE, IMF, and past studies as the primary requirement to develop a system story. The study used a qualitative approach to narrate the design and understanding of the problem and issue quantitative solutions for real-life scenarios. The model used environmental tax (Ecotax) as a policy variable to reduce pollution emissions and enhance the

revenue from this tax to improve economic growth and address social equity by improving per capita income. The study identified pollution intensity as the driver of ecotax and examine the effect of these taxes on reducing emissions, enhancing economic prosperity, and maintaining environmental sustainability. The standard system dynamics modeling and application is given below:

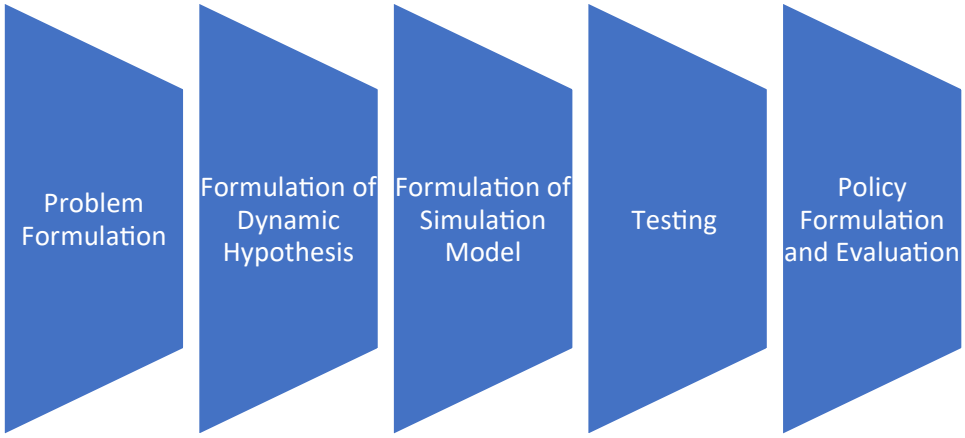


Fig 3.1 Standard System Dynamics Modeling

3.2 Data sources

System dynamics starts with the understanding of the real problem based on the qualitative data collected through discussions with stakeholders at UNDP and the environmental protection agency. These stories will be substantiated with the data collected from secondary sources such as NBE, world bank, IMF and UNDP, UNEP OECD to design preliminary conceptual. other reports published by the Government of the federal republic of Ethiopia: Department of Environmental Affairs, Department of Energy and National Treasury, national bank of Ethiopia, and Publications by the African Development Bank, Africa Institute, and Overseas Development Institute are important in conducting system development research because it provides comprehensive perspectives on the study, contributes to validation and cross-checking findings,

and compensates for the limitations of one method of data collection with the strengths of the others (Patter, 1990).

Data regarding GDP, pollution intensity, pollution emission, population, population growth rate, trade openness, and energy consumption have been collected from the stated sources, and other variables are generated through simulation.

The baseline or initial sample data for macroeconomic variables is taken from 2010 onwards this is due to the green economy initiative being introduced to the economic policy discussion in 2009/10. And inclusive green growth discussion is only a recent phenomenon and was raised as an initiative in Rio in 2014.

3.3 Method of Data Analysis

The data will be analyzed using Vensim software which will generate simulation results of the effects of various ecotax policies on the GDP and other macroeconomic variables. The simulation result is also used to see the distribution of ecotax revenues to subsidies for green investment and their roles in promoting green growth.

3.4 The system dynamics model

This study used a more comprehensive model in addition to the one used by Block et al. (2013) which focused on the relationship between GDP, and consumer debt (including public debt and income inequality within a national economy). It was designed to see the correlation between income inequality and debt crises. The model used two groups to examine income inequality in the economy. The groups include the investors who don't need to adjust their consumption because of lack of money and the Non-investors who need to adjust their consumption based on the money available this will resemble the model used by Kumhof et al (2010).

System dynamics allows for the contextualization of the model to fit the real problem and in line with this, the study made significant changes to the previous models. This includes the stock and flow variables and auxiliary and exogenous variables.

The previous model used GDP as an auxiliary variable but this study assumes GDP as a stock variable driven by annual growth rate and the share of ecotax revenue. The unit of measurement for GDP is birr which is translated from dollar-reported GDP based on the currency conversion rate of the reporting period in this case 2010 and the annual GDP growth rate of 11.2 percent is used for simulation.

The ecotax rate is defined as the rate of tax imposed on the level of pollution at the macro level. The emission data was calculated based on emission intensity obtained from the world bank multiplied by GDP. This explains the level of pollution emission caused to produce one unit of output measured in birr. The new model takes into account the effect of ecotax as a sustainable economy doesn't necessarily result in a green economy. Ecotax promotes environmental behavior and it is charged on the resources that have non-renewable traits. Ecotax plays a significant role in promoting investors to invest in green technologies and systems of production (green investment) instead of classical capacity which intern preserves non-renewable resources and decreases pressure on the environment.

This study does not specifically identify the polluter pays principle as it leaves it for further studies. The tax base used to levy the tax is the aggregate pollution emission in the economy discussed in the above paragraph. The tax revenue levied on the pollution will be redistributed partly on green investment and the remaining amount will be added to the GDP to improve the per capita income and support social equity as well.

Among the proxies used to capture social equity is per capita income, which is measured as the percentage of GDP to the population. The study assumes that the tax collected from emissions will be recycled to the households in the form of GDP and which intern will intern improve their welfare. The study has also tried to see if taxes imposed on emissions affect energy consumption and force the government to invest more in climate change and direct households and businesses to use less polluting technologies.

3.5 Causal Loop Diagram

The critical step in the system dynamics model is to draw a feedback system through a causal loop diagram. CLD captures the causes of the dynamics and mental model; it also structures and communicates the key feedback processes to assume to cause of the problem (Sterman, 2000).

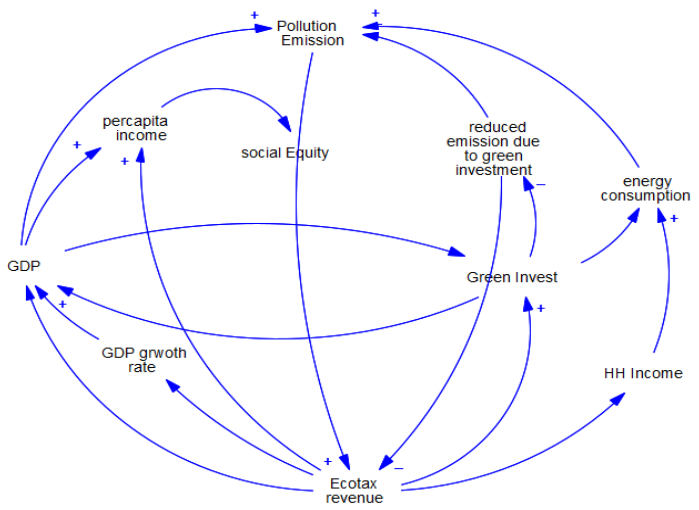


Fig 3.2 Causal loop diagram for pollution emission and ecotax: Authors' Design 2023

Feedback loops: Ecotax revenues can be reinvested in sustainable projects, leading to green growth and job creation. Higher ecotax rates can incentivize businesses and individuals to adopt greener practices, leading to reduced emissions and pollution. Green financing availability can

stimulate investment in sustainable industries, further promoting inclusive green growth. Sustainable practices and technologies can lead to productivity improvements, economic competitiveness, and increased financial support.

3.6 Stock Flow Diagram

Stock and flow (or Level and Rate) diagrams are ways of representing the structure of a system with more detailed information than is shown in a causal loop diagram. Stocks (Levels) are fundamental to generating behavior in a system; flows (Rates) cause stocks to change. Stock and flow diagrams are the most common first step in building a simulation model because they help define the types of variables that are important in causing the behavior. This study is built on two stock variables GDP and population. The inflows from GDP are generated from the growth rate as a function of initial GDP and the ecotax revenue collected as a result of emission. The other stock variable is the population which is affected by the population growth rate and initial population. Other than the stock variables, there are multiple auxiliary and constant variables used to develop a more customized version of the model generated by Block et al (2013). Fig …. Below shows the stock flow variables of ecotax and pollution emission.

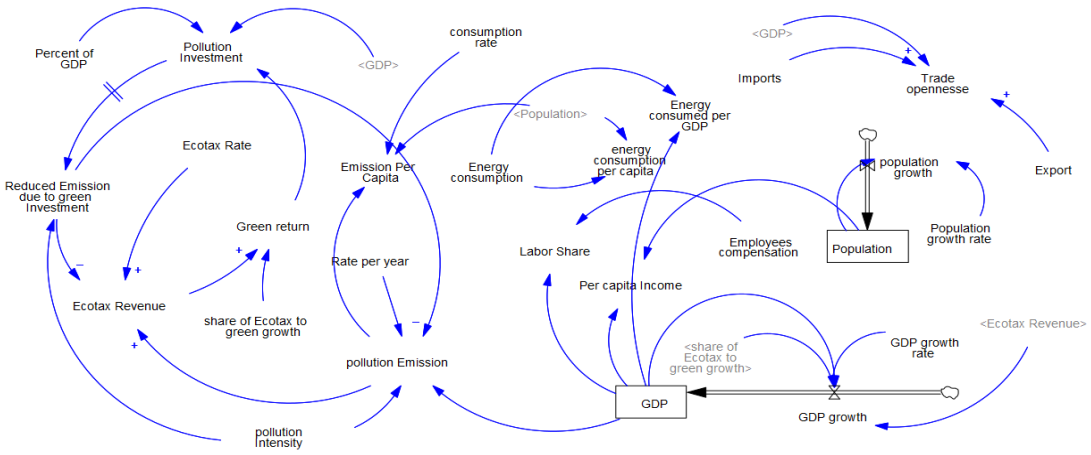


Fig 3.3 Forester diagram for Ecotax

Table 3.1 Description of Variables in the System

SN.	Variable	Unit	Predicting variables
1	Pollution Emission	Tons/Year	Pollution Intensity, GDP, And Reduced Emission Due To Green Investment
2	Ecotax Revenue	Birr/Year	Ecotax Rate, Pollution Emission, And Reduced Emission Due To Green Investment
3	Ecotax Rate	Birr/Tons	Exogenous
4	GDP	Birr/Year	GDP Growth Rate And Ecotax Revenue
5	Per Capita Income	Birr/Person	Population And GDP
6	GDP Growth	1/Year	Exogenous
7	Green Return	Birr/Year	Ecotax Revenue And Share Of Ecotax Revenue
8	Green Investment	Birr/Year	GDP And Green Return
9	Reduced Emission Due To Green Investment	Tons/Year	Green Investment And Pollution Investment
10	Revenue Share To Green Investment	Dmnl	Exogenous
11	Population	Person	Population Growth
12	Population Growth Rate	Person/ Year	Exogenous
13	Energy Consumption	Gwh	Exogenous
14	Emission Per capita	Tons/Person	Pollution Emission And Population
15	Energy Consumption Per GDP	Gwh/Birr	Energy Consumption And GDP
16	Trade Openness	1/Year	Import Export And GDP

Chapter Four

Results and Discussions

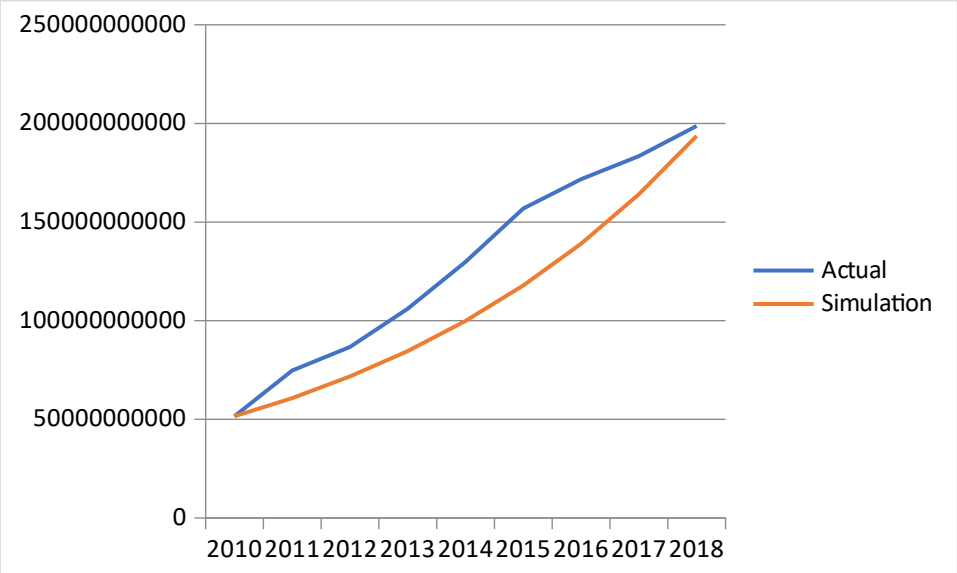
4.1 Introduction

This chapter tries to address the issue of inclusive green growth and sustainable finance through the introduction of Ecotax in Ethiopia. The data has been collected from various institutional databases to understand the real context of the problem and after that, the study applied a system dynamics model to see the relationship between various variables and draw conclusions.

4.2 Model Testing

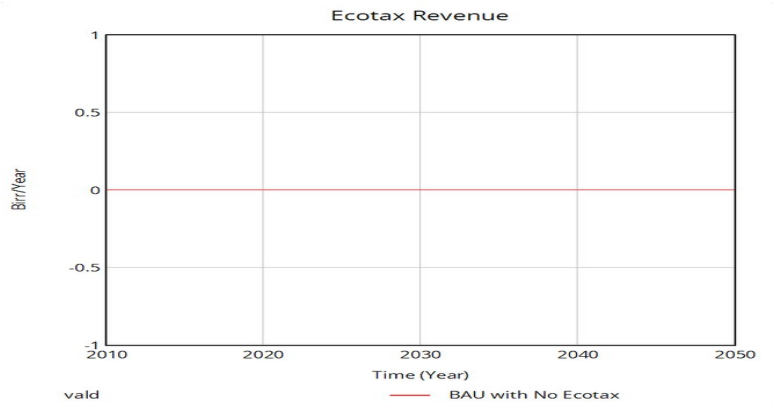
4.2.1 Data validation

Validation of data that has been collected from various sources on pollution emission, economic growth, and other policy-relevant variables actual data aligns with the data generated through simulation in system dynamics. The validation of the data sketch gives confidence in the model and the research result which can be used as a policy recommendation. **Fig 4.1 Data validation**



4.2.2 Extreme Value Test

The study used Ecotax shares distribution on green investment, economic growth, and social equity to see if the extreme values affect the result of the simulation. The revenue generated from the environmental tax is examined to check on the business as usual(BAU) scenario, and the distribution of the revenue in its entirety to green investment and economic growth simultaneously. **Fig 4.2 Extreme value test**



4.2.3 Behavioral Reproduction Test

This model is undertaken to check if the model reproduces the behavior of interest which in this case is pollution emission. The behavioral tests will address if imposing ecotax will reduce pollution emissions and enforce economic growth and social equity. To do so the study compared the model output and data and shape of the variables with the previous findings and literature and found the model is behaviorally good.

4.2.4 Parameter confirmation

The purpose of this test is to examine if the parameter values are consistent with relevant descriptions and numeric knowledge of the system. it also checks for the alignment of the variables with real-world counterparts. Actual data from various stakeholders especially the

Ministry of Planning, UNEP, UNDP, and EU reports have been used to check and validate the proxies of each parameter value.

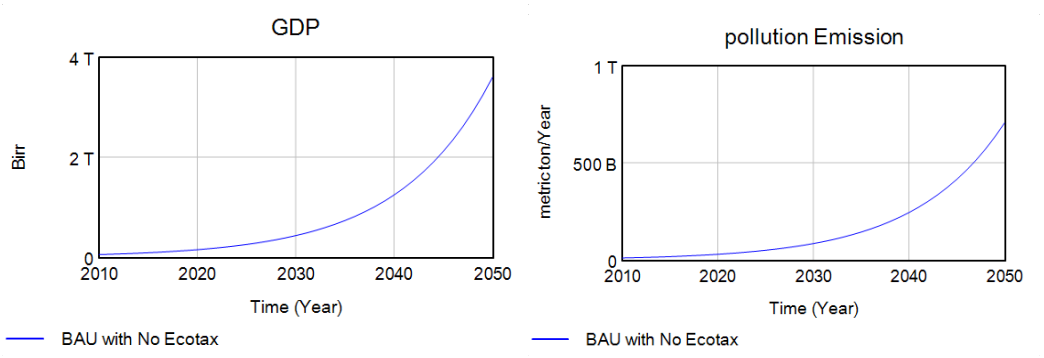
4.3 Simulation Results and Analysis

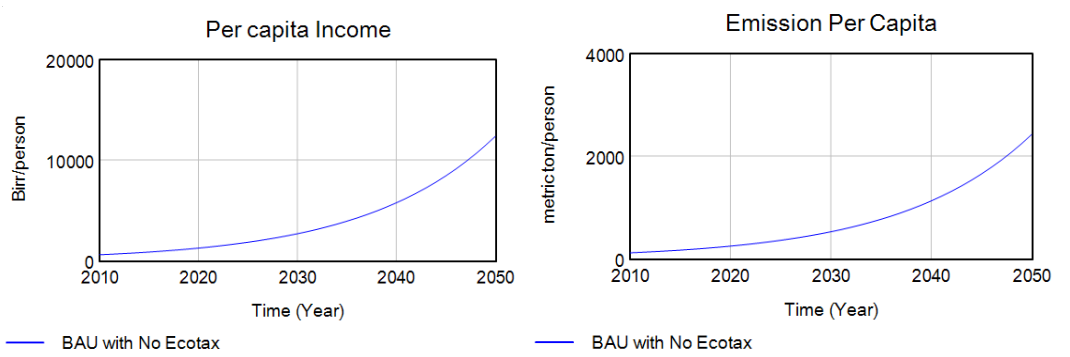
Based on the model validation test and current policy tools various scenarios have been developed. Namely business as usual (BAU 1) scenario 1, where the model assumes no ecotax and revenues are generated from the emission. Scenario two(BAU 2) where ecotaxes will be levied on the pollution emission however the revenue generated will be entirely transferred to economic growth. Scenario 3 (BAU3) assumes the government levy taxes on emissions and the revenue generated from the pollution will partly (20%) be invested in green investment and the remaining 80% will be injected into the economy. Scenario 4 will assume a different share of green investment and GDP by taking into account 80% of the revenue generated to be invested in green investment and the remaining 20 be injected into the economy.

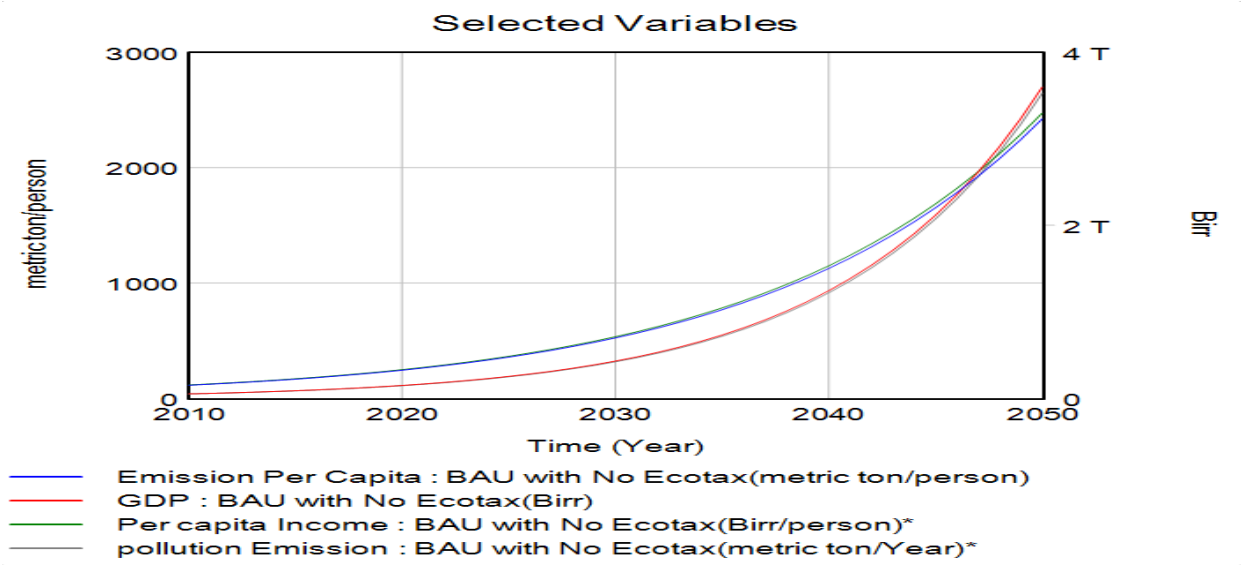
4.3.1 BAU Scenario 1: Non-sustainable Growth

Here the study assumes business as usual as can be recalled from previous discussions there are no environmental taxes (ecotax) in Ethiopia. Therefore, there won't be any tax collected from pollution as the result of the socio-economic damages assumed to endure continues.

Figure 4.3 Scenario one







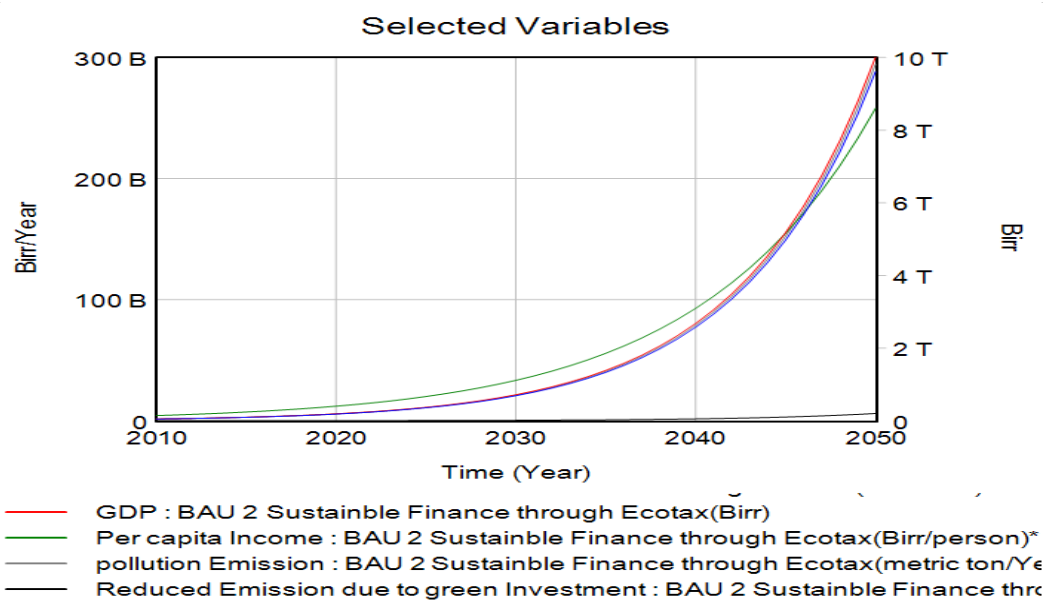
4.3.2 Scenario One: A Non-Sustainable Economic Growth

It is quite obvious that GDP has long been criticized for its lack of inclusiveness and its limitation to show the quality of life. The main target of this study is to incorporate these dimensions into the model and show that economic growth should entertain inclusiveness and work for a sustainable environment. The baseline scenario does exactly that and shows an economy with no due diligence to the environment and social equity. The drive for the study was economic growth initiates pollution which comes from an increased use of resources and higher human activity. And as can be seen from the charts, a prospering economy almost equally yields

a high level of emission. This increase in economic growth for obvious reasons increased per capita income with it. This increase in per capita income is unsustainable as it comes with environmental costs, which intern enforces household income to be used for health and other damages caused by pollution. These findings are similar to the findings of Block et al (2013) where they have stated the economy with no Ecotax reports unsustainable growth which will not address the environmental and social consequences.

4.3 Scenario Two: Sustainable Finance through Ecotax

Figure 4.4: Scenario two: Sustainable Finance through Ecotax

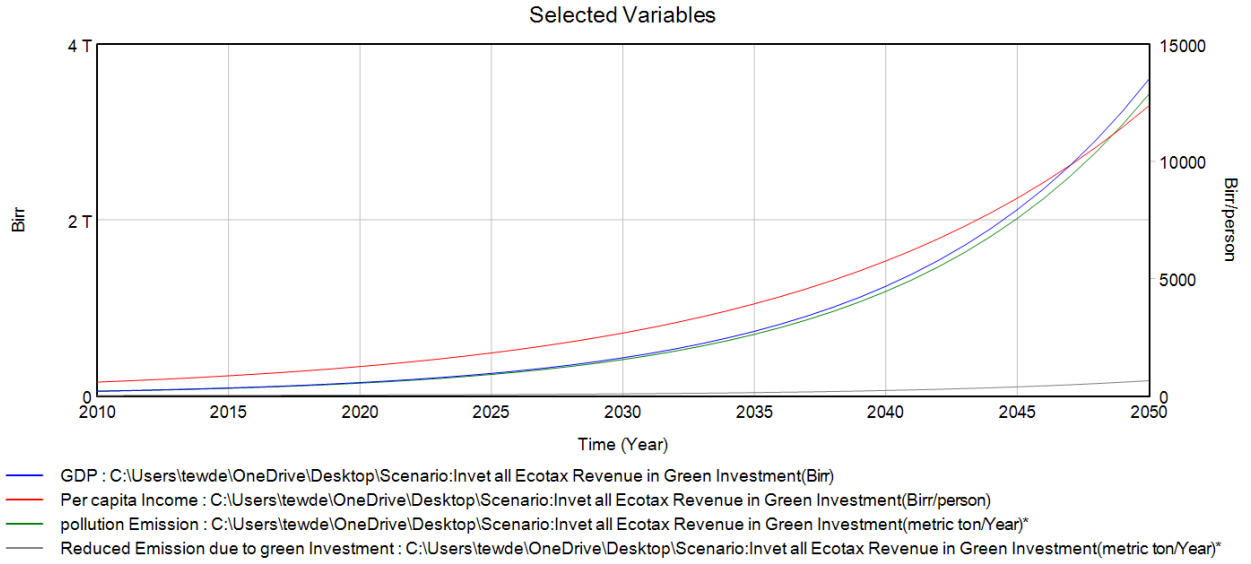


The second scenario introduces ecotax as a means of sustainable finance but the revenue generated from pollution emissions is entirely injected into the economy to minimize income inequality. As a result of this policy, the study showed an increase in income per capita which will promote social welfare. The most noticeable result is as the revenue generated from the environment is added to the existing GDP, it will drive pollution higher but due to the non-investment of revenue generated from pollution in green investment, reduced emission due to

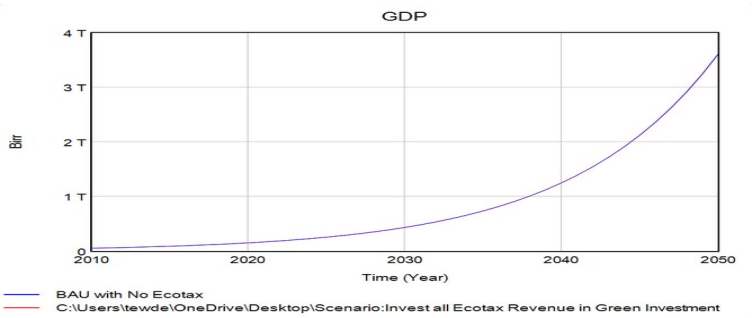
green investment is almost nonexistent as a result pollution and percapita pollution increases. Ecotaxes have short-term negative economic effects, however, their redistributive trait will contribute to sustainable long-run economic development. This scenario rather has minimal ecological impact as the entire revenue generated is added to economic growth and no reinvestment is made on pollution reduction.

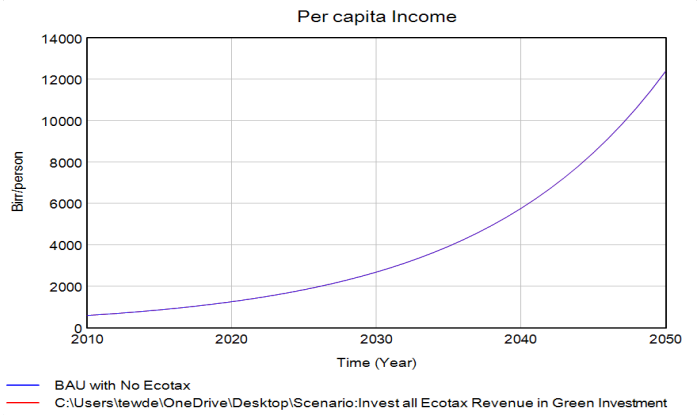
4.4 Scenario Three: Invest all Ecotax revenues in Green Investment

Figure 4.5: invest all Ecotax revenues in Green Investment



The expected result from this scenario is whether green investment can reduce pollution and the scenario analysis showed that if the revenue generated from pollution is put into green investment, the reduced pollution from a green investment will be significantly high. Interestingly the economy will be able to grow equally with the first baseline scenario without costing the environment and disrupting the existing income inequality as can be seen from the figure below:





International studies showed environmental tax to be a real policy variable for a green economy. This study tried to show the relationship between pollution emission, economic growth, green investment, and per capita income when imposing ecotax. This paper confirms the view in the literature mathematically that imposing environmental tax plays an active part in green development. The role of an environmental tax on green development is reflected in this study by the comparison of the evolution of green development indicators between different scenarios. On one hand, when an environmental tax has been levied, some indicators deviate away from their null case without environmental tax. The relative indicators show that environmental tax can promote economic growth, and save resources. To make Ecotax more effective, the revenue collected from pollution needs to be recycled through investment in green technologies, infrastructures, and subsidies to e-vehicles.

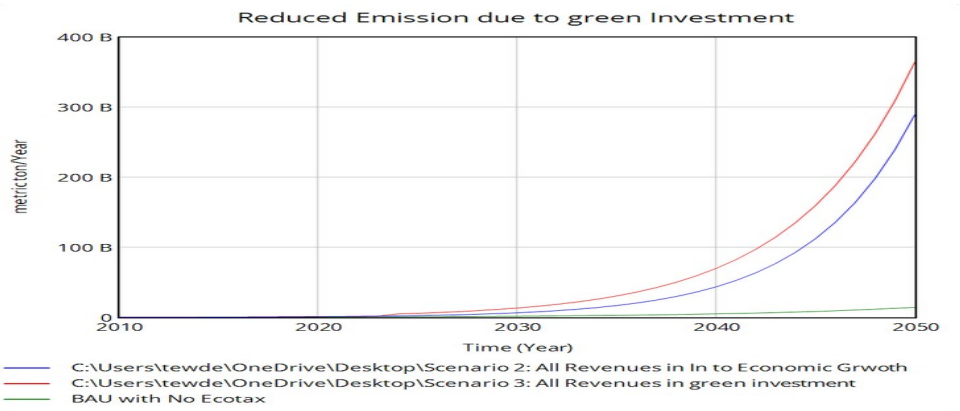
4.5 Objective 1. Ecotax, Sustainable Finance, and Economic Growth

As discussed in the previous chapters Ethiopia's climate finance of 85% to 90% was financed by loans and grants. This has made the government policy regarding climate change highly dependent on external sources while the remaining 10 to 15% is financed from the treasury. Regardless of consistent reported economic growth the country is unable to raise finances internally for sustainable development goals. Hence the economic growth reported will only result in unsustainable growth. This research tried to link ecotax revenue as a means of sustainable finance to support sustainable economic growth. The findings showed that imposing environmental-specific tax will support economic growth (GDP) and reduce pollution emissions. This is because ecotax is levied on the pollution within the economy and the amount generated will be injected back into the green investment to impact pollutive behavior and at the same time it reduced the revenue generated from the environment due to reduced emission. The findings of this study are inline with the previous findings of Block et al (2013), they have claimed that an increase in economic activity enforces pollution emission and this need to be financed through debt and revenue generated through eco tax.

4.6 Objective 2: The Role of Ecotax in Reducing Greenhouse Gas Emissions

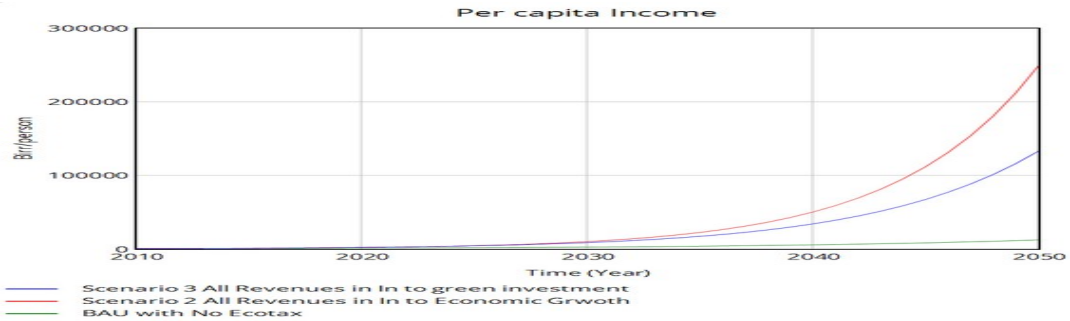
As Juili Yin et al (2019) and Guo (2016) showed in their previous findings imposing environmental taxes on pollution has significantly reduced the extent of emission discharged and based on the three scenarios this study clearly showed the relevance of introducing environmental tax in the economy. Without ecotax, the extent of economic, social, and environmental damages is severely high. Drought, lack of agricultural productivity, and health crises will be imminent.

Figure 4.6 : Reduced Greenhouse Gas Emissions



The study tried to show the economy in various scenarios: scenario one being there are no environmental taxes, scenario two imposes Ecotax and invests all the revenue generated into the economy, and scenario three uses all the Ecotax revenues for green investment. Where the investment in a green environment is minimal pollution disrupts the economy. Having no ecotax yields relatively less reduced emissions due to green investment (7%) than imposing ecotax on pollution and using all the revenues on non-sustainable growth (15%). That is because the economy uses the revenue generated to sustain the environment to a non-sustainable growth. Where are if the revenues generated from ecotax are reinvested into a green investment, the reduced pollution from the scenario will be higher (17%).

4.7 Objective 3: Environmental Tax and Income Inequality



One of the primary goals of this study was to see the implication of imposing ecotax on social welfare. Based on the three scenarios observed, imposing an environmental tax will indeed

contribute to sustainable growth and maintain social income equality in the process of meeting the very need for inclusive green growth. The household per capita income reported minimal progress when there was no ecotax in place. The result of imposing ecotax and reinvesting the entire revenue on green investment has shifted the per capita income significantly. The more non-sustainable change in per capita is reported when the revenue generated from pollution is injected into economic growth in its entirety pushing the per capita income line higher. The majority of studies conducted by Block (2013), Guo (2016), Juili et al (2019), and Gupta (2016) all claimed that a periodic increase in GDP results in a non-sustainable economic growth. Therefore for the economy to generate sustainable growth it should work in line with maintaining social equity.

4.8 Objective 4: Impact of Ecotax on Trade Openness

The most obvious role that ecotax can play in trade openness is through imports and exports. Environmental taxes both affect the location production to the extent of emission release and imports based on the content of the material purchased to climate change. The study also confirmed that trade openness reported higher values in the absence of ecotax due to the price effect on exports and imports.

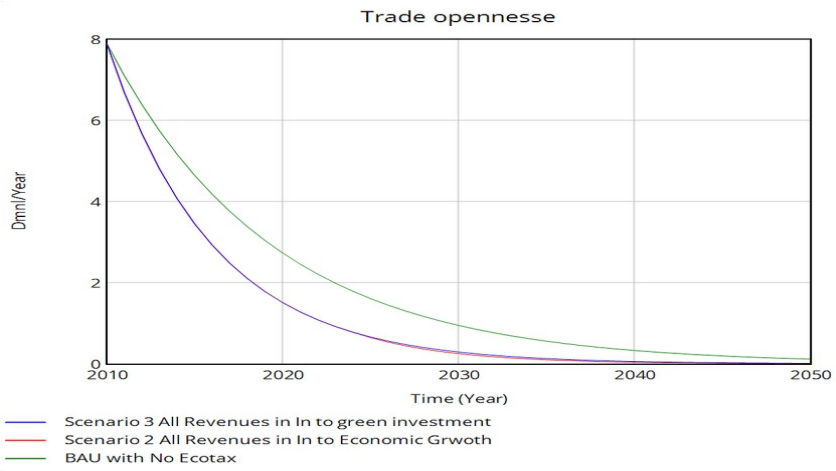


Fig 4.7 Ecotax and Trade Openness

The effect of ecotax on trade openness can vary depending on several factors, including the design and implementation of the ecotax, the specific industries and products affected, and the response of trading partners. Ecotaxes imposed on certain goods or industries can increase the cost of production or importation, which may make imports more expensive compared to domestically produced goods. As can be seen from the data, can lead to reduced imports and potentially restrict trade openness. If ecotaxes are not applied uniformly across countries or regions, it may create imbalances in competitiveness. Countries with lower or no ecotaxes on similar products may gain a competitive advantage, in the long run leading to trade imbalances and affecting trade openness.

As policy option ecotaxes can incentivize the shift towards more sustainable and environmentally friendly products or production methods. This shift in consumer preferences and industry practices may result in changes in trade patterns, with increase in demand for certain types of goods such as electric cars and decrease demand for others. It is also important to note ecotax can also create opportunities for trade in green or sustainable products and technologies.

Chapter Five

Summary of Findings, Conclusion, and Recommendation

5.1 Introduction

Based on the previous models developed by Block (2013) and customizing the model to fit the Ethiopian context, the study tried to examine the nexus between sustainable and non-sustainable economic growth, pollution emission, and ecotax that can be generated based on pollution intensity of the country. Ecotax or environmental taxes have not been introduced into the Ethiopian tax system but there are other taxes such as excise tax and customs duties which are levied for the same purpose. This chapter discusses the major findings based on the simulation results and discussions based on the previous chapters.

5.2 Summary of Major Findings:

- The first scenario the study tried to observe was business as usual where the country imposes no taxes on pollution and the economy will report non-sustainable growth. In the absence of environmental taxes, the government will only consume less than 2% of its GDP annually to mitigate climate change. As a result, the economy reported a significant increase in pollution emissions by the current trend is expected to reach 240% by the year 2050.
- Another source of non-sustainable growth comes with the injection of the total tax into green investment. The discussion in the previous chapter showed the government only spends less on the environment which comes from the treasury. Since the significant climate finances are generated from external sources such as loans and grants it only exasperates Ethiopian dependence on foreign aid to mitigate climate change.

- On the other extreme, the study tried to examine if the total tax revenue generated is injected into the economy, the economy will report significant growth at the cost of the environment. More economic growth without reinvestment in climate change will not sustain the growth. Therefore an improvement that comes with this policy will increase GDP and per capita income but the consequences on the environment will be higher and will increase pollution by 17%.
- One of them of inclusive green growth is that the economy should respond to social equity and work on the quality of growth not just the quantity. This has been the major limitation of measuring economic growth taking GDP as a proxy. Therefore, the study findings showed t make growth more inclusive ecotaxes should be used to balance economic growth, environmental sustainability, and social welfare through the redistributive nature of the tax.

5.3 Conclusion

The study tried to provide valuable insight into the complex dynamics and interdependence of ecotax policies, environmental factors, economic growth indicators, and social factors. y incorporating feedback loops and simulating the model over time, it becomes possible to understand the long-term effects of ecotax policies on inclusive green growth and sustainable finance.

The study result also showed how the introduction of ecotax can influence economic growth, guide a sustainable environment and maintain social equity. Through the research it was also possible to see investment in green share can limit the extent of pollution and reduce the amount of revenue generated from ecotax. Due to its price effect on imports and export, ecotaxes also showed a negative impact on trade openness.

5.4 Recommendation

Based on the discussions of the result and the findings the study recommended the following important policy tools to enhance economic growth, environmental sustainability, and social welfare.

- Though taxes have been introduced in the Ethiopian tax proclamation for social and environmental purpose, it only comes in the form of excise tax. the findings suggest that imposing ecotax will improve environmental sustainability and social equity. Therefore, the government should consider a specific tax on pollution emissions to apply the polluter pays principle.
- Based on the first scenario analysis, economic growth with no environmental concern is non-sustainable and economic prosperities will be consumed by environmental costs. Therefore, the government should increase financing green investment beyond the current two percent.
- Since green investment aligns with inclusive green growth policy, the government should continue its effort such as green legacy and subsidizing electric cars.
- As a review of empirical studies shows, imposing ecotax has administrative challenges and consumes economic resources. Therefore, empowering the tax authorities with the necessary technology and understanding of environmental tax will Sufic the redistributive nature of the tax.
- If imposed, taxes collected from pollution emissions should be partly invested in green investment.

5.5 Direction for Future Studies

This study was based on the model developed by Block (2013) and the model was redesigned to meet the Ethiopian context. However, the study didn't incorporate all the variables stated in the previous model which would have made the model more comprehensive. Also, this study does not show the extent of the distribution of income or pollution from various sectors and this has been a challenge in the past as it is in the present. Therefore, future researchers can take off from here and design a micro-level analysis and show the implication of distributing the aggregate ecotax or imposing a specific rate of ecotax in different sectors and clearly show how growth can be inclusive and sustainable in the long run.

References

AfDB (2014), *Green Growth in Africa, Supporting Africa's Transition to Green Growth; Snapshot of the African Development Bank's Activities.*

African Development Bank. (2012*). Facilitating Green Growth in Africa: Perspectives from the African Development Bank;* Discussion paper.

Aleksandar Vasilev (2018): Optimal fiscal policy with environmental tax and pollution abatement spending in a model with utility-enhancing environmental quality: *lessons from Bulgaria, Macroeconomics and Finance in Emerging Market Economies*, *DOI: 10.1080/17520843.2018.1522360.*

Andrea M. Bassi, valeria costantini. (2020). *Systemic modeling tools to assess the green economy transition*.

Block 2013 Joachim Block, Bo Hu, and Stefan Pickl: *Inclusive growth and sustainable finance - a system dynamics model. The 2013 International Conference of the System Dynamics Society, Proceedings*, Cambridge, MA, USA, July 21 – July 25, 2013

Bordo 2012 Michael D. Bordo and Christopher M. Meissner: Does Inequality Lead to a Financial Crisis? *NBER Working Papers, No. 17896,* National Bureau of Economic Research (NBER), Cambridge, MA, USA, March 2012.

Canis 2013 Bill Canis: Battery Manufacturing for Hybrid and Electric Vehicles: Policy Issues. *CRS Report for Congress, CRS Report for Congress,* US Congressional Research Service, Washington, DC, USA, 4 April 2013

Cottrell, J., Bridle, R., Yongqiang, Z., Jingli, S., Xuxuan, X., Beaton, C., …Cheng, H. (2013). Green revenues for green energy: Environmental fiscal reform for renewable energy

technology development in China. Winnipeg, Canada: International Institute for Sustainable Development (IISD)/China National Renewable Energy Centre (CNREC). Retrieved from http://www.iisd.org/ pdf/2013/china_green_revenue_en.pdf

Desalegn, G., Tangl, A., & Fekete-Farkas, M. (2022). *Greening through taxation: assessing the potential opportunities and challenges of plastic products in Ethiopia*. *AIMS Environmental Science*, *9*(4), 432-443.

Ethiopia's Climate Resilient Green Economy National Adaptation Plan the Federal Democratic Republic of Ethiopia, n.d.

Forrester, J.W., 1968. *Principles of systems*. MIT Press.

Fitiwi, M. (2014). *The Need for Environmental Tax in Ethiopia: Economic Analysis of Law*. *Mekelle ULJ*, *2*, 102.

Federal Democratic Republic of Ethiopia Ministry Of Environment, *Forest And Climate Change National Redd+ Secretariat National Redd+ Strategy Ackno*wledgements, 2018.

Fan X, Li X, Yin J (2019) *Impact of an environmental tax on green development: A nonlinear dynamical system analysis*. PLoS ONE 14(9): e0221264. https://doi.org/10.1371/journal.pone.0221264

Federal Democratic Republic Of Ethiopia Ministry Of Environment, Forest And Climate Change National Redd+ Secretariat National Redd+ Strategy Acknowledgements. (2018).

Gebregiorgs, T. (n.d.). *Introducing an Administratively Feasible Environmental Tax System in Ethiopia*. 327–374.

Guo, L.-l., et al., Identifying a pathway towards green growth of Chinese industrial regions based on a system dynamics approach. Resour Conserv Recy (2016),

http://dx.doi.org/10.1016/j.resconrec.2016.09.035.

Habtamu Alemu Jano (2015), *Climate Change Financing in Ethiopia, University of Antwerp Institute of Development Policy and Management.*

Heine, D., Norregaard, J., Parry, I. W. H., Evans, D., Johannes, S., Küchler, S., Nguyen, H., Nguyen, H. K., Schlegelmilch, K., Smith, K., & Sterner, T. (2012). *Environmental Tax Reform: Principles from Theory and Practice to Date; by Dirk Heine, John Norregaard, and Ian W.H. Parry; IMF Working Paper 12/180; July 1, 2012*.

Hu 2010 Hu, B.; Pickl, S.: Analysis and Design of International Emission Trading Markets Applying System Dynamics Techniques. *Daniel M. Dubois Editor: Computing Anticipatory Systems: CASYS `09: Ninth International Conference on Computing Anticipatory Systems, AIP Conference Proceedings, Volume 1303,* 408-415

Jha, S., Sandhu, S. C., & Wachirapunyanont, R. (2018). Inclusive Green Growth Index: A New Benchmark for Quality of Growth. In *Asian Development Bank* (Issue October). https://www.adb.org/publications/inclusive-green-growth-index

J.K. Musango, et al., Modelling the transition towards a green economy in South Africa, Technol. Forecast. Soc. Change (2014), http://dx.doi.org/10.1016/j.techfore.2013.12.022

Kumhof 2010 Michael Kumhof and Romain Rancière: Inequality, Leverage and Crises. *Douglas Laxton (Ed.): IMF Working Papers, WP/10/268,* International Monetary Fund (IMF). Washington DC, USA, November 2010

Li, M.; Zhang, Y.; Fan, Z.; Chen, H. Evaluation and Research on the Level of Inclusive Green Growth in Asia-Pacific Region. Sustainability ***2021****, 13, 7482. https://doi.org/ 10.3390/su13137482*

Lu, Y. (2010). Enhancing green tax measures in Hong Kong: A means of addressing the city's environmental problems (Master's thesis, Lingnan University, Hong Kong). Retrieved from http://dx.doi.org/10.14793/acct_etd.4

Meadows 1972 Donella H. Meadows, Jorgen Randers, Dennis L. Meadows, William W. Behrens: The Limits to growth: A report for the Club of Rome's Project on the Predicament of Mankind. *ISBN 0876631650, Universe Books, New York, 1972*

M.T., G. (n.d.). *Greening the Ethiopian tax system at the confluence of environmental justice and development Gebregiorgs, Merhatbeb*.

MOP. (2022). *Federal Democratic Republic of Ethiopia Third National Communication (NC3) of the Federal Republic of Ethiopia*. *December*.

OECD 2011 OECD: Environmental Taxation - A Guide for Policy Makers. *Taxation, Innovation and the Environment,* OECD, September 2011

OECD 2012 OECD: Inclusive Green Growth: For the Future We Want. *Secretary General of the OECD Editor: OECD Work,* OECD, Paris, France, 2012

Padmanabhan, R. (2022). *The landscape of Climate Finance in Ethiopia*. *November*. *Towards green growth* (Issue May 2011).

Pigou, A.C. (1920). *The Economics of Welfare*. Fourth edition. London: Macmillan and Company Limited.

Rajat Verma (2016*): Ecotaxes: A Comparative Study of India and China, The Institute for Social and Economic Change*, Bangalore Institute; working paper series 353.

Sterman, J.D., 2000, *Business Dynamics - Systems Thinking and Modelling for a complex world*. Irwin McGraw-Hill, New York, US.

UNEP, 2014, *Using models for green economy policymaking*. United Nations Environment Program, Nairobi, Kenya

UNEP, Towards a green economy: pathway to sustainable development and poverty eradication, Nairobi: UNEP: http://www.unep.org/greeneconomy/greeneconomyreport/tabid/29846/default.aspx 2011.

USAID 2016, *Climate Change Risk Profile. Ethiopia Fact Sheet*.

Thomas Conefrey , John D. Fitz Gerald , Laura Malaguzzi Valeri & Richard S.J. Tol (2013) The impact of a carbon tax on economic growth and carbon dioxide emissions in Ireland, *Journal of Environmental Planning and Management, 56:7, 934-952, DOI: 10.1080/09640568.2012.70946.*

Appendix: list of Equations

consumption rate= Units: 1/Year

Ecotax Rate=0+STEP(0.15, 2024) Units: Birr/metric ton

Ecotax Revenue=SIMULTANEOUS (
  (Ecotax Rate*pollution Emission)-(Reduced Emission due to green Investment
*Ecotax Rate),
    1.2e+10)
Units: Birr/Year
Emission Per Capita=
  pollution Emission/Population/consumption rate
Units: metric ton/person

Employees compensation=
  5.81988e+11
Units: wages

Energy consumed per GDP=
  Energy consumption/GDP
Units: GWH/Birr

Energy consumption=
  40000

Units: GWH

energy consumption per capita=
    Energy consumption/Population
Units: GWH/person

Export=
    1.01643e+11
Units: Birr/Year

GDP= INTEG (
    GDP growth,
        5.15079e+10)
Units: Birr

GDP growth=
    GDP*GDP growth rate+Ecotax Revenue*(1-share of Ecotax to green growth)
Units: Birr/Year

GDP growth rate=
    0.18
Units: 1/Year

Green return=
    Ecotax Revenue*share of Ecotax to green growth
Units: Birr/Year

Imports=
    3.05372e+11
Units: Birr/Year

Labor Share=
    Employees compensation/GDP
Units: wages/Birr

Per capita Income=
    GDP/Population
Units: Birr/person

Percent of GDP=
    0.02
Units: Dmnl/Year

pollution Emission=
    pollution Intensity*GDP*Rate per year-Reduced Emission due to green Investment
Units: metric ton/Year

pollution Intensity=
    0.08
Units: metric ton/Birr

Pollution Investment=
    GDP*Percent of GDP+Green return
Units: Birr/Year

Population= INTEG (
    population growth,
        8.92378e+07)
Units: person

population growth=
    Population*Population growth rate
Units: person/Year

Population growth rate=
    0.03
Units: 1/Year

Rate per year=
    1
Units: 1/Year

Reduced Emission due to green Investment=
    Pollution Investment*pollution Intensity
Units: metric ton/Year

share of Ecotax to green growth=
    1
Units: Dmnl

Trade opennesse=
    (Export+Imports)/GDP
Units: 1/Year