ASSESSMENT OF SUSTAINABLE RURAL ROAD CONSTRUCTION APPROACH: THE CASE OF WEST ARSI ZONE, OROMIA, ETHIOPIA

HUSSEIN SULTAN SANI

A THESIS SUBMITTED TO THE DEPARTMENT OF CIVIL ENGINEERING

SCHOOL OF CIVIL ENGINEERING AND ARCHITECTURE

PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER'S IN CIVIL ENGINEERING

(Specialization in Construction Engineering and Management)

OFFICE OF GRADUATE STUDIES

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

August, 2023 G.C.

Adama, Ethiopia

ASSESSMENT OF SUSTAINABLE RURAL ROAD CONSTRUCTION APPROACH: THE CASE OF WEST ARSI ZONE, OROMIA, ETHIOPIA

HUSSEIN SULTAN SANI

MAIN ADVISOR- BAHIRU BEWKET (PhD)

A THESIS SUBMITTED TO THE DEPARTMENT OF CIVIL ENGINEERING

SCHOOL OF CIVIL ENGINEERING AND ARCHITECTURE

PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER'S IN CIVIL ENGINEERING

(Specialization in Construction Engineering and Management)

OFFICE OF GRADUATE STUDIES

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

August, 2023 G.C.

Adama, Ethiopia

Declaration

I hereby declare that this Master Thesis entitled “Assessment of Sustainable Rural Road Construction Approach: The Case of West Arsi Zone, Oromia, Ethiopia” is my original work. That is, it has not been submitted for the award of any academic degree, diploma, or certificate in any other university. All sources of material that are used for this thesis have been duly acknowledged through citation.

_____	_____	_____
Name of student	Signature	Date

Recommendation

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "Assessment of Sustainable Rural Road Construction Approach: The Case of West Arsi Zone, Oromia, Ethiopia" prepared under my guidance by Hussien Sultan Sani submitted in partial fulfillment of the requirement of the Degree of masters in Construction Engineering and Management.

Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

_____	_____	_____
Major Advisor	Signature	Date

APPROVAL SHEET

I, the advisor of thesis entitled "Assessment of Sustainable Rural Road Construction Approach: The Case of West Arsi Zone, Oromia, Ethiopia" and developed by Hussien Sultan Sani, hereby certify that the recommendation and suggestions made by board of examiners are appropriately incorporated into the final version of the thesis.

_____	_____	_____
Major Advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis have read and evaluated the thesis entitled "Assessment of Sustainable Rural Road Construction Approach: The Case of West Arsi Zone, Oromia, Ethiopia" and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Construction Engineering and Management.

_____	_____	_____
Chairperson	Signature	Date
_____	_____	_____
Internal Examiner	Signature	Date
_____	_____	_____
External Examiner	Signature	Date

Final approval and acceptance of the thesis is contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

_____	_____	_____
Department Head	Signature	Date
_____	_____	_____
School Dean	Signature	Date
_____	_____	_____
Office of Postgraduate Studies, Dean	Signature	Date

ACKNOWLEDGEMENT

First of all, I would like to thank the Almighty Allah, who gave me the commitment and tolerance to pass various obstacles and come up to the accomplishment of this thesis work.

Next, I would like to send my deepest gratitude to my advisors Dr. Bahiru Bewket (PhD) for his excellent advice and guidance with professional with his knowledge and appropriate information.

Furthermore, I would like to thank Adama Science and Technology University, school of Civil Engineering and Architecture and post graduate Office for providing good atmosphere to cope up with this final year thesis study and Mrs. Yodit F., Civil Engineering and Architecture Department Head for her best treatments and advice in shaping me for the best output of this thesis.

TABLE OF CONTENTS

LISTS OF FIGURES

LISTS OF TABLES

LISTS OF EQUATION

ABSTRACT

Over the years, the discussion of sustainability has centered on the interaction of its three key dimensions: economic, environmental, and social, as well as the need to better integrate these three dimensions to achieve desired development outcomes. Rural road construction in developing countries has not taken geology, topography, or land use into account, which has resulted in a variety of issues, such as land sliding and erosion. Thus, this study investigates the sustainability of rural road construction in the West Arsi Zone, Oromia region, Ethiopia. The population of the study comprised the client, construction (contractors and consultants) organization, and displaced households those lives in the area of rural road construction projects and systematic sampling was used as the sampling technique of the research to extract the sample, in which 50 sample size were selected. Primary data was collected directly from a questionnaire survey and interview and the collected data for the study was analyzed, using the Statistical Package for Social Sciences, version 20. The result of the study was presented with frequencies, percentages, mean scores, interpretation of mean scores, and ranks. As the finding indicated that the construction process was not adopt sustainable rural road construction approach in terms of environmental, social and economic indicators. So, this study concludes that the cost of sustainable construction, the availability of human resources and sustainable materials hampers, Lack of knowledge of sustainable rural road construction, government policies, weather condition, and market incentives are significant factors to the adoption of sustainable rural road construction and finally, based on the findings of the study, construction industry stakeholders need to develop a mechanism for overcoming the natural factors that hamper the implementation of sustainable road construction.

Keywords: - *Rural road, environmental sustainability, social sustainability, economic sustainability.*

CHAPTER ONE

1. INTRODUCTION

1.1.Background of the Study

The concept of sustainability dates back nearly 40 years and is based on the belief that economic growth and industrialization can be achieved without harming the environment. The United Nations 2005 World Summit (Outcome Document) reaffirmed economic development, social development, and environmental protection as "interdependent and mutually reinforcing pillars" of sustainable development. Over the years, the discussion of sustainability has centered on the interaction of its three key dimensions: economic, environmental, and social, as well as the need to better integrate these three dimensions to achieve desired development outcomes(Program et al., 2012).

As a concept, sustainability generally denotes a balance of economic, social, and environmental goals with a long-term (intergenerational) concern. In transportation projects, SA is applied to evaluate whether a project “contributes to favor economic development and fulfill the transportation needs of the society in a manner consistent with ecological and human values”. SA is an advanced methodology to ensure that decision-making is comprehensive and inclusive, meaning that it covers all three dimensions/pillars of sustainable development (i.e., environmental, social, and economic dimensions), including the indirect effects. Political ambition can play a huge part in the planning of road projects (Gyadu-Asiedu et al., 2021)..

Such projects have vital roles in enhancing regional growth and economic competitiveness, especially in developing countries. However, environmental aspects are relatively neglected and frequently only incorporated later on. Traditional impact assessment tools are often solely concerned with the environmental dimension, while the social and economic dimensions are less often considered for strategic environmental assessment of transportation projects. This paper focuses on road infrastructure projects because of their impacts on the environment and society. These projects are often key drivers of landscape transformations, habitat fragmentation, and societal change on both global and local scales, with impacts lasting for long periods and producing intergenerational consequences. Therefore, a better inclusion of sustainability dimensions is needed (Lombard & Coetzer, n.d.2019).

Investing in transportation infrastructure is critical for rural revitalization and agricultural production. It is a critical and leading industry in the national economy, as well as a significant service industry. Improving transportation infrastructure can boost agricultural labor productivity by allowing labor to be transferred to the nonagricultural sector, allowing labor to be transferred to cities to earn more money. Rural road construction is also central to the alleviation of rural poverty and has a close synergy with rural livelihood outcomes such as increased incomes, increased social well-being, reduced vulnerability, improved food security, and more sustainable use of natural resources(Gómez-Cabrera et al., 2020).

Nonetheless, the majority of Sub-Saharan Africa's low-volume rural roads are unpaved. They are vital to rural communities' socioeconomic factors and well-being. The majority of rural roads in those countries are built on lateritic or gravel soils. Rural roads in Sub-Saharan Africa face major challenges due to a lack of funding and engineering input during both construction and maintenance activities. Rural roads are generally in poor condition for these reasons and become nearly impassable during the rainy season due to erosion processes that severely damage them. The poor condition of rural roads has serious ramifications for the economic transport of goods and services, as well as the overall mobility of people, impeding the country's development(Lombard & Coetzer, n.d.2019).

Furthermore, Ethiopia's development has been hampered by a lack of infrastructure; the country has one of the lowest road densities in Africa. To sustain economic growth and poverty reduction initiatives, the government must address Ethiopia's severe infrastructure constraints. Roads are a critical enabling condition for improving rural living conditions. The distribution of socioeconomic benefits resulting from a rural road, on the other hand, is a separate issue, and there are no guarantees or inherent mechanisms in place to ensure that these benefits are distributed equitably among the poor and nonpoor in communities. For example, Ethiopia is implementing the Universal Rural Road Access Program (URRAP) to liberate the country's rural people from access constraints, reduce rural poverty, improve welfare and opportunity, stimulate agro-productivity, and share growth - growth that benefits the poor. Its mission is to build all-weather roads that connect all of Kebele. Road infrastructure will be built to meet the needs of rural communities while remaining affordable to build and maintain(Asomani-Boateng et al., 2015).

However, studies have shown that road construction is not always environmentally, economically, or socially sustainable. It places more restrictions on the environmental goals of rural sustainable development, particularly the rational use of land.

On the one hand, rural roads have enormous environmental and social costs during construction and operation(Iimi et al., 2015) Rural Road construction, on the other hand, will result in issues such as land fragmentation and deterioration of arable land layout. These factors severely restrict the sustainable development of the economy, environment, and society (Gyadu-Asiedu et al., 2021).

In less developing countries, including Ethiopia, sustainability of the rural road construction approaches are not investigated deeply. Thus, this study investigates the sustainability of rural road construction in the West Arsi Zone, Oromia region, Ethiopia.

1.2.Statement of the problem

Sustainable rural road construction is an important issue that has recently attracted the attention of policymakers worldwide. The United Nations 2005 World Summit (Outcome Document) reaffirmed the 'interdependent and mutually reinforcing pillars' of sustainable development as economic development, social development, and environmental protection. It is assumed that trade-offs are always possible between the environmental, social, and economic dimensions. In practice, development programs, while allowing for tradeoffs, put greater emphasis on the economic dimension (and in that dimension, growth generally takes precedence over distribution).

A distinction is often drawn between 'strong' sustainability (where such trade-offs are not allowed or are restricted) and 'weak' sustainability (where they are permissible). maintain that there is no agreed-upon and universally accepted metric for defining the extent and level of sustainability achieved in development programs. Sustainability and sustainable development tend to be ethical concepts to express the desirability of good environmental and social outcomes from economic decision-making(Marsden, Kimble, et al. 2010).

Nonetheless, rural road construction in developing countries has not taken geology, topography, or land use into account, which has resulted in a variety of issues, such as land sliding and erosion. As a result, construction must take into account the geology of the country, as even

minor mistakes can destabilize the social and natural environment. Particularly in the context of mega-rural road projects with larger catchments, this can cause a slew of social, economic, and environmental issues(Mulmi 2009).

In addition, in less developed countries, plans to increase economic value production, but the environment was not included in the planning and implementation of development activities. Development activities with the potential for economic benefit posed a significant risk of environmental adversity. Environmental and social concerns were undermined because they were viewed as roadblocks to development. However, the consequences of past environmental neglect are visible today. Some of the negative consequences include land loss, siltation, landslides, soil erosion, and biodiversity loss. Furthermore, the rural road construction problem was prevalent, which is a result of defective construction methods and an overlook of the environment (Sun and Meng 2009).

Thus, the sustainability of infrastructure development is an issue of growing concern and calls for close examination of the design, construction, and maintenance of road infrastructure. In developing countries such as Ethiopia, technical knowledge of infrastructure development in rural mountainous regions is still limited, which results in technical shortcomings and significant environmental impacts. There is a shortage of studies on the sustainability of rural road construction in our country. To fill these gaps, the researcher will conduct a sustainable rural road construction approach in the west Arsi zone, Oromia, Ethiopia.

1.3. Objective of the study

1.3.1. General objective

The general objective of this study is to assess the sustainability of the rural road construction approach, in the case of West Arsi Zone, Oromia, Ethiopia.

1.3.2. Specific objectives

- To identify the factors influencing the implementation of sustainable rural road construction in the case of West Arsi zone, Oromia regional state.
- To investigate the benefits of sustainable rural road construction based on economic, social, and environmental factors in the case of West Arsi Zone of Oromia regional state.
- To examines barriers to the implementation of sustainable rural road construction in the case of West Arsi Zone of Oromia regional state.

1.4. Research questions

- What are the factors influencing the adoption of sustainable rural road construction in the case of West Arsi zone, Oromia regional state?
- What are the benefits of sustainable rural road construction based on economic, social, and environmental factors in the West Arsi Zone of Oromia regional state?
- What are the barriers that hinder the adoption of sustainable rural road construction?

1.5. Significance of the study

The study is important to the West Arsi Zone, Oromia Road, and Ethiopia Road Authority, which is in charge of developing Ethiopia's road system because it identifies the implications of previous developments on rural road development, and this information can be used to develop better policies and plans that will ensure that benefits are fully realized and negative effects of future road developments in Ethiopia are minimized. This study also helps policymakers and other concerned bodies to assess the problems related to rural road construction and address them to ensure the sustainability of rural construction. This study will also use a reference point for further study in the areas as well as use the literature in the study to guide their studies.

1.6. Scope and Limitations.

The study is limited to rural road construction in the West Arsi zone of Oromia region. The study was done using a mixed research approach to understand the sustainability of the rural road construction approach in the study area. The data for this study were collected from the roads, targeting respondents and institutions that are located in the study area.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Introduction

Since the late 1980s, the emergence of the sustainable development concept has sparked interest from academia, government agencies, business organizations, and civic communities in developing a tool to help decision making towards sustainability, called sustainability assessment (SA). SA refers to "a methodology that can help decision-makers and policy-makers decide what actions they should take in an attempt to make society more sustainable". The main aim of SA is to ensure that plans and activities make an optimal contribution to sustainable development. SA has increasingly become a common practice in various areas, such as product, policy, and institutional appraisals, as well as in project evaluations. As a concept, sustainability generally denotes a balance of economic, social, and environmental goals with a long-term (intergenerational) concern. In transportation projects, SA is applied to evaluate whether a project "contributes to favor economic development and fulfill the transportation needs of the society in a manner consistent with ecological and human values". SA is an advanced methodology to ensure that decision-making is comprehensive and inclusive, meaning that it covers all three dimensions/pillars of sustainable development (i.e., environmental, social, and economic dimensions), including the indirect effects. Political ambition can play a huge part in the planning of road projects (Gómez-Cabrera et al., 2020).

Such projects have vital roles in enhancing regional growth and economic competitiveness, especially in developing countries. However, environmental aspects are relatively neglected and frequently only incorporated later on. Traditional impact assessment tools are often solely concerned with the environmental dimension, while the social and economic dimensions are less often considered for strategic environmental assessment of transportation projects. This paper focuses on road infrastructure projects because of their impacts on the environment and society. These projects are often key drivers of landscape transformations, habitat fragmentation, and societal change on both global and local scales, with impacts lasting for long periods and producing intergenerational consequences. Therefore, a better inclusion of sustainability dimensions is needed (Asomani-Boateng et al., 2015).

In other words, sustainability development is the development that meets the needs of present without compromising the ability of future generations to meet their own needs. It contains two key concepts within it: the concept of 'need', in particular, the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environments ability to meet present and future needs. The United Nations 2005 World Summit (Outcome Document) reaffirmed economic development, social development, and environmental protection as "interdependent and mutually reinforcing pillars" of sustainable development. Over the years, the discussion of sustainability has centered on the interaction of its three key dimensions: economic, environmental, and social, as well as the need to better integrate these three dimensions to achieve desired development outcomes.(Program et al., (2012)).

Investing in transportation infrastructure is critical for rural revitalization and agricultural production. It is a critical and leading industry in the national economy, as well as a significant service industry. Improving transportation infrastructure can boost agricultural labor productivity by allowing labor to be transferred to the nonagricultural sector, allowing labor to be transferred to cities to earn more money. Rural road construction is also central to the alleviation of rural poverty and has a close synergy with rural livelihood outcomes such as increased incomes, increased social well-being, reduced vulnerability, improved food security, and more sustainable use of natural resources.(Gómez-Cabrera et al., 2020).

2.2. Theoretical Studies on Socioeconomic Benefits and Impacts by Road Development

Theory is a set of explanatory concepts that is useful for explaining a particular phenomenon, situation or activity. Since the research process is not divorced from theory, this study has employed theory of evaluation among others under which programme theory and change theory are used as tools for checking the road development impacts in the study areas. Programme theory is the issue of intervention by actors such as the government, private companies etc for the project formulation and implementation, whereas, change theory is about the impact created due to the interventions. Therefore, using theory as the research base has a paramount importance not to wander aimlessly. The four stages (inputs, outputs, outcomes and impacts) in the project cycle are about both change theory and programme (intervention) theories. Under

each component, the impact pathway is growing with the continuum of multiple change processes due to the intervention.

According to Khandker et al (2010) evaluation approaches for development programme had evolved significantly over the past two decades aimed at helping policy makers decide whether the drawn projects are generating intended results; to promote responsibility and answerability in the allocation of resources across public programmes; and to fill the gaps in understanding what works or not, and how measured changes in the well-being of the community are attributable due to a particular project or policy intervention. Given the availability of sufficient data, QED can be performed after a programme has been implemented. Based on this, Edwards (2000) had outlined the guides in impact evaluation and noted that development impact assessment is designed to assess the impacts taking place at one point in time and space. In other words he pointed that it would have to be adapted to understand the impacts of many increments of development over time (temporally) or across an extensive area (spatially). In conclusion, as many literatures depicted, it can be generally understood that, in theory, roads facilitate rural development; new roads will improve transport; improved transport will solve access problems; improved access enhances living conditions and income earning opportunities. Improved living conditions and income saving opportunities foster further development. In the next chapter, the research design is formulated to check the impact theories discussed.

2.3. Empirical Studies on Socioeconomic Benefits and Impacts by Road Development

Infrastructure investments especially in rural road development enhances access to markets for inputs such as fertilizers and improved seeds and enables the farmers to sell their produce to nearby markets through a reduction in transport fare and time (Raballand et al, 2010). On the other hand, the lack of road network can lead to increased transaction cost in rural areas which results in limited market access for farmers (Key, de Janvry, and Sadoulet, 2000). In developing countries like Africa, transport cost constitutes more than half of the marketing costs (Fafchamps, Minten, and Eleni, 2005). Hence such roads are vital in improving agricultural productivity and raising living standards in poor rural areas (Gannon and Liu, 1997).

Rural roads also allow farmers to achieve additional non-farm employment opportunities, leading to a rise in income and reduce rural poverty (Ali and Pernia, 2003). Rural roads improve mobility which in turn facilitates access (Donnges, 1998). In China, Fan and ChanKang (2005) found that rural roads have benefit–cost ratios for national GDP that are about four times greater than the benefit–cost ratios for highquality roads. As far as agricultural GDP is concerned, high-quality roads do not have a statistically significant impact while lowquality roads are not only significant but also generate 1.57 yuan of agricultural GDP for every yuan invested. Investment in low-quality roads also generates high returns in rural non-farm GDP. It also lift more urban as well as rural poor out of abject poverty than do high quality roads. Using state level data from India in 1970-93, Fan and Thorat (2000) found that government spending on rural roads have larger poverty reducing impacts per rupee spent than any other government investment and generate higher productivity growth.

Similarly using household level data from Nepal, Jacoby (2000) showed that providing extensive roads access to markets would lead to substantial benefits on average especially to poor households. In three Africa countries-Burkina Faso, Uganda and Zambia, using village level data, Barwell (1996) showed that proximity to an active local urban center and to a main road, complemented by good rural road access, has a positive influence on the level of household income; and good road access broadens the economic opportunities available to rural people. In most African countries women and children shoulder most household transport burden and make significant contribution to the agricultural efforts of the household, including frequent trips to the field for cultivation activities. It significantly reduces the transport burden of women and children (Barwell, 1996). Using Generalized Methods of Moments and controlling for household fixed effects, Dercon et al, (2008) found that access to all-weather roads reduces poverty by 6.9 percentage points and increases consumption growth by 16.3 percent in Ethiopia.

Road infrastructure and the spread of extension services have contributed to growth and poverty reduction in rural Ethiopia (Dercon et al, 2007). Improvement in road infrastructure resulting from large scale public investment programme like RSDP1 also contributed positively to the size and structure of the manufacturing sector in Ethiopia (Admasu et al; 2012). Bryceson, Bradbury and Bradbury (2008) found that in extremely

remote areas, road improvements may catalyze the expansion of social-service provision, as evidenced in Ethiopia. However, given the poor's relative lack of motor vehicles and ability to pay for public transport, they are, by no means, a sufficient condition for enhancing the mobility of the rural poor. Most of the above empirical evidences and others on impact of roads on socio economic conditions are analyzed using quasi-experimental methods and on wealth differentiated approaches. Attempts to delineate the road influence on the basis of distance from road, understand threshold type trends and map the influence zone on socio economic outcomes are scanty at best. Road influence zone analysis has been used to analyze influence of roads on ecological and environmental effects of road but not on socio economic conditions. This study is the first attempt to quantify and map out the influence zone of roads on socio economic outcomes.

2.4. Road Infrastructure in Ethiopia

Three perspectives can explain why road construction has been a domain of the state in Ethiopia. First, from an economic perspective, road infrastructure is a classic example of a public good that is characterized by non-excludability. As a consequence, the private sector has no interest in providing roads (Tunji-olayeni et al., 2016). Hence, road construction has been a domain of the Ethiopian state throughout its history. Second, from a political perspective, road infrastructure and the accessibility of peripheral rural areas are of crucial importance for the state's "…monopoly on the legitimate use of physical force in the territory it is said to control" (Herbst 2000:21). From this point of view, it is argued that the construction of roads has played a significant role in the consolidation of the Ethiopian state since its very beginning (Garg & Yadav, n.d.2017). Third, from a development perspective, road infrastructure constitutes a precondition and decisive factor for the development and has, therefore, to be provided by the state. Road infrastructure in Ethiopia has had great strategic, political, economic, and social significance. The literature and documents on past road infrastructure often draw a clear line between different Emperors' and regimes' motivations to construct roads. However, the significance of roads can hardly be reduced to one single aspect for the era concerned but indicates the discursive justification of its construction for the regime concerned.

2.5. Road Classification in Ethiopia

Since 1951, the road network in Ethiopia has become increasingly differentiated, which is expressed by how it has been classified. In general, three different systems of classification can be distinguished: technical, functional, and political classification .

First, the technical classification categorizes roads based on their technical standards. Rather simple classifications are made according to different surface types, widths, or the road's traffic carrying capacity (Annual Average Daily Traffic (AADT) (ERA 2002b:1). A more detailed technical classification is based on the application of the ten Design Standards (DS), which have recently been defined by the Ethiopian Roads Authority (ERA). They clarify "the principal geometric features ...[as] the road cross-section and horizontal and vertical alignment"9. Despite the strictly technical formulation of the design standards, they meet a variety of objectives for road users (e.g. safety or traffic volume), for the implementation (e.g. economic and financial considerations, construction technologies) as well as for the particular location of the road (e.g. topology, land use, environment) (ERA 2002a:1).

Second, the functional classification categories roads according to their significance for the mobility of people and goods. In particular, trunk, link, main access, collected tor, and feeder roads are distinguished (ERA 2002a:3). The terminology used for this classification implicitly indicates the connection to a policy focus on socio-economic development.

Third, the political classification categorizes roads according to the levels of the decentralized political system responsible for the administration of roads. Consequently, the recently existing road network can be classified into 20,429 km of federal roads, 23,930 km of regional roads, and 70,038 km of community roads (ERA 2008b:25-27). In addition, a certain politico-functionalist classification can be identified emphasizing the relation or connection between the decentralized levels. In this context, the road network is categorized into kebele-kebele, kebele-woreda, woreda-woreda roads, etc. (cf. Fortune 2010).

2.6. Definition of Rural Roads

Rural roads have been defined from various perspectives, depending on the level of development of a country and the specific technical and socio-economic aspects of the road. The International Labor Organization defines rural roads as all publicly owned roads whose primary purpose is to provide direct access for rural villages and communities to economic and social services (Das Mulmi, 2009). This definition may be insufficient as it may be neglecting the importance of

roads, tracks, and paths owned by local governments and communities, commonly known as Rural Transport Infrastructure (Lebo, 2000). A broader perspective is considered by the International Development Association (IDA), the World Bank's fund for the world's poorest countries, which defines rural roads as all other roads than main roads (Das Mulmi, 2009). This comprehensive definition may differ significantly between countries according to their socioeconomic condition. In developed countries, rural roads are generally structurally designed low-traffic facilities connecting towns with low populations with primary and secondary networks. Meanwhile, in developing countries rural roads are commonly unpaved low-volume roads designed to meet the social and economic needs of the rural population (Kehagia, 2009). The rural network in developing countries commonly represents 80% of the total road network lengths, and carries 20% of the total motorized traffic, but provides access to the majority of the population to main roads and social networks (Kehagia, 2009).

In this thesis, rural roads are considered as unbound gravel and earth roads, paths and tracks serving low volume traffic, less than 300 Average Annual Daily Traffic (AADT) and non-motorized traffic (including haulage carts, bicycles, and pedestrians), designed to meet the social and economic needs of the rural population in a developing country. With this, production roads specially designed for the exploitation of natural resources, such as forestry and mining roads, are excluded from the analysis. Considering a three-level hierarchy network, rural roads are usually secondary and tertiary/access roads in rural areas. Tertiary/access roads are tracks or very simple earth roads that begin at the farm/village level and connect the rural population to the secondary network. These are usually seasonal roads with low serviceability levels transited by nonmotorized traffic and motorized traffic at low speeds. Secondary roads are earth or basic gravel roads which serve the needs of low-volume traffic of conventional vehicles and non-motorized vehicles. These roads are connected to the primary network, which are engineered all-season roads that present higher levels of heavy load motorized traffic and connects cities and towns (Chaka Advisor & Atsede Tesfaye, 2021).

2.7. Rural Roads Characteristics

Rural roads in developing countries are typically non-engineered unpaved roads, paths, and tracks presenting low-volume traffic and non-motorized traffic that serve the rural population. These are also referred to as unsurfaced, unpaved, and unbound roads. Unpaved roads can be

defined as all roads where vehicles travel directly upon a gravel or soil layer (Garg & Yadav, n.d.2018). The roads are classified as earth tracks, earth roads, and gravel roads. As defined by the Department of Transportation of South Africa the main characteristics of unpaved roads are (Montgomery et al., 2015):

- Earth tracks generally consist of parallel ruts separated by vegetation, delineating a lightly trafficked rural access path. These tracks are not engineered and are often impassable during wet weather conditions. In most cases, they carry less than five vehicles per day. They are not constructed or maintained by a road authority, instead, they are managed by local communities and only sporadically by local road agencies. They are an important means of access by non-motorized traffic such as pedestrians, bicycles, and animal-drawn carts.
- Earth roads, also referred to in the literature as dirt roads, are those where no imported gravel is used, but the in situ material is cleared of vegetation and lightly compacted. The roads may be shaped making use of the material which is removed from the side of the road during the construction of side drains. In this way, a small embankment is formed and the road is raised slightly. These roads are usually constructed by a road authority or local agencies and are important for the economic or social advancement of the area. Unlike earth tracks, periodic maintenance should be applied to earth roads.
- Gravel roads consist of a layer of imported selected natural soil or gravel material which is typically constructed to a specified standard and provides an acceptable all-weather surface. The vertical and horizontal alignment is generally upgraded to the desired standards. Maintenance of gravel roads is carried out on a more regular and systematic.

2.8. Socioeconomic Impacts of Road Infrastructure Development

Long term development benefits are among others likely to result from road investment interventions and in the long run vice versa. This means transport development presupposes economic development and economic development gains further presupposes road infrastructure development in terms of quality, technology and expansion. The quality and efficiency of road development impacts on quality of the social system, and the continuity of economic activity which assist multidirectional growth by reducing transport costs and improve the environment by removing unsuitable roads (Wimpy 2005).

However, road is not always useful in and of itself, but the benefit comes when it allows users better and better which impacts through accessibility to various opportunities. As pointed above, impacts of a road infrastructure development can be seen in terms of the local impacts as well as in wider regional and national perspectives. The local impact is expected to be limited to the immediate neighborhoods of the highway. That is, to the towns and villages lying on both sides of the highway within an average distance of commonly 5 to 7 or 10 kms defining the influence zone (Vogel and Stephenson 2012:26; Sengupta et al 2007:10). The entire regional or national economic space beyond these neighborhoods should also benefit from the development through progressive spread effect. Such effect may be called the regional or national level impacts.

Further, the impact may be direct or indirect in nature. It may be mentioned in this context that the indirect effects on income, output, employment, land rent and land price and poverty are realized not only in the local economies in the proximity of the highway, but are also spread throughout the regional and the national economy by way of various linkage effects (Sengupta et al 2007:10). In line with this, this research focuses to assess the socioeconomic benefit and its environmental impacts of rural road in the case of URRAP road program in Woliso Woreda. Socioeconomic development in this study refers to a process of improving the quality of life and level of well-being or prosperity of a local community. Increased employment opportunities, increased household income, promoting access to services and emerging socioeconomic activities, improved local infrastructures such as roads, health, education and housing, are all facets of socioeconomic development (Edward, 2000).

2.9. Environmental impacts of road development

Infrastructure, in general, defines as a set of facilities through which goods and services are provided to the public. Its installations do not produce goods and services directly but provide inputs for all other socio-economic activities. Infrastructure is the stock of basic facilities and capital equipment needed for the functioning of a country or area; the term to refer collectively to the roads, bridges, rail lines, and similar public works that are required for an industrial economy, or a portion of it, to function.

Economic and social development of Ethiopia is significantly dependent on efficient road transport infrastructure which facilitates delivery of agricultural produce, merchandise and commodities to markets as well as easy access to basic services (health, schools, water, trading centers, and administrative offices etc.) by the people. The benefits from efficient road transport are felt at all levels of the society, directly or indirectly, such as to include improved national economy, social income, wealth and job creation, health care, public transport and general service delivery. Improvement of all these areas is desirable for the current national aspirations including inter-sectoral growth collaborations (Perkins, 2011). Success of Vision 2030 initiative is basically a function of the infrastructure, efficient road network being the key unit.

Development of new roads and improvement of existing facilities have potential negative effects to the physical environment and social wellbeing of the communities as well as natural habitats. Among the potential negative impacts from road construction projects could include: environmental pollution from construction activities, risk to health and safety of the residents and employees, demand of construction materials such as water, wood, gravel and hard stones; increased run off, socio-cultural changes including loss of farming land, changes of domestic and wild animals access to water point, demolition of structures, displacement of human settlement/commercial centers, interference with animal reserves and foot paths, increased traffic, increased ambient air pollution, increased potential for road accidents, increased surface run off, flooding and associated disasters among other impacts. Other anticipated impacts from road projects is disruption of natural habitats by interference of food chains and breeding sites and habitats, risks of fatal wildlife attack, displacement or extinction of species, destruction of land, vegetation, introduction of exotic species and possible interference with natural eco-balance.

2.9. A Sustainable Approach to Road Construction

Conventional development focused only on the final product. The method exploited nature and the people. The wider exploitation of nature leads to environmental problems, land degradation, and climatic changes. Likewise, it has generated a wider disparity between the haves and the haves not which has created the hierarchies of people, gender, and culture. Figure 2.1 addresses the need for a sustainable development approach to doing any work. The sustainable

development model addresses all the issues which are not addressed by the conventional form of development. Poverty alleviation measures, consideration of basic needs of people. Productive employment, environmental consideration, and appropriate technology are some of the paradigms considered by the sustainable development models which contributed to reducing the gap between the haves and the haves not (Das Mulmi, 2009).

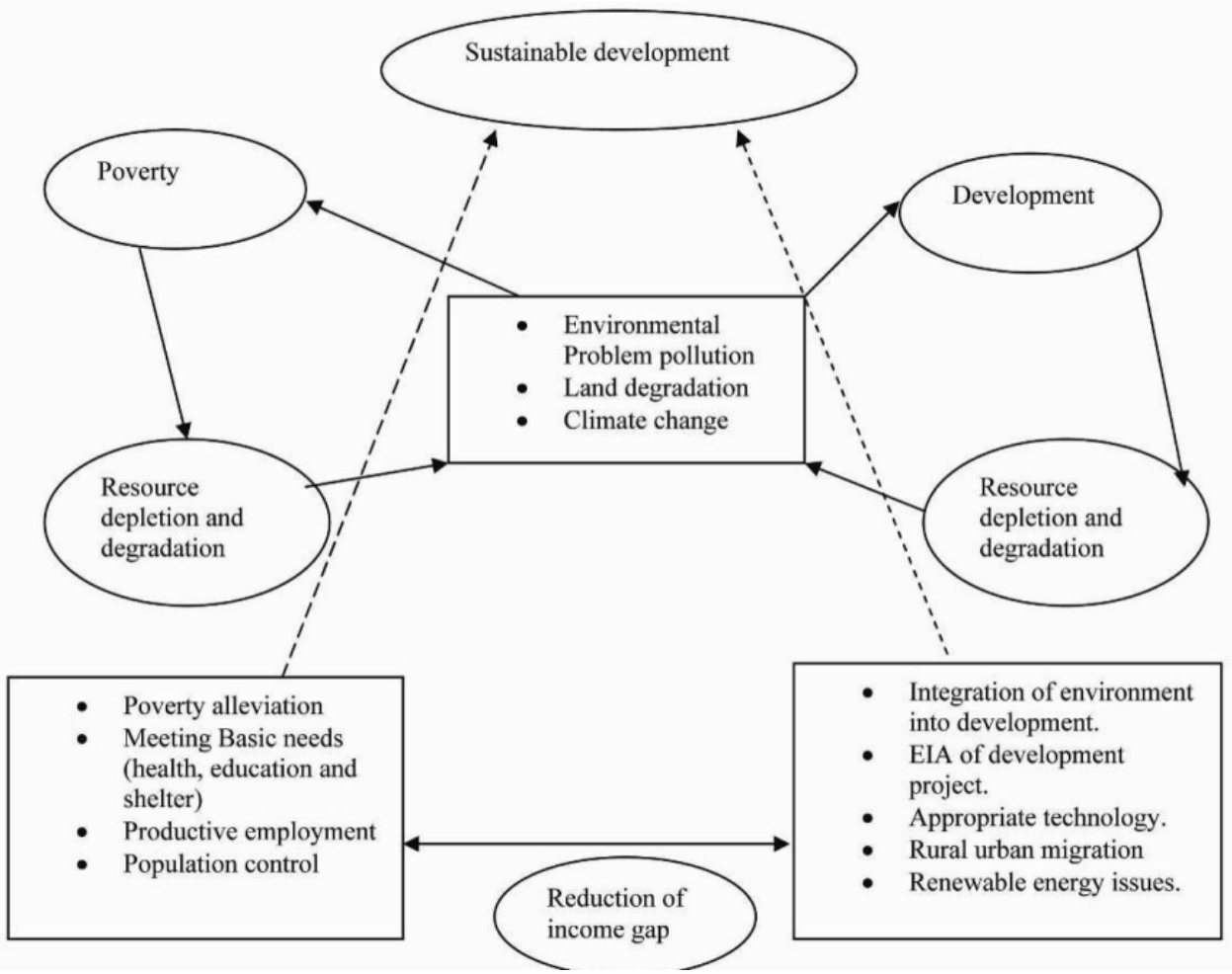

Figure 2.1- Need of sustainable development (Source: Uprety BK, 2008).

World Commission on Environment and Development (WCED) in 1987 defines Sustainable development as "a development, which meets the needs of the present without compromising the ability of future generations to meet their own needs." In general, Sustainable development comprises the three broad pillars social, environmental, and economic accountability, often known as the 'triple bottom line' these themes/pillars are also shown in Figure 2.

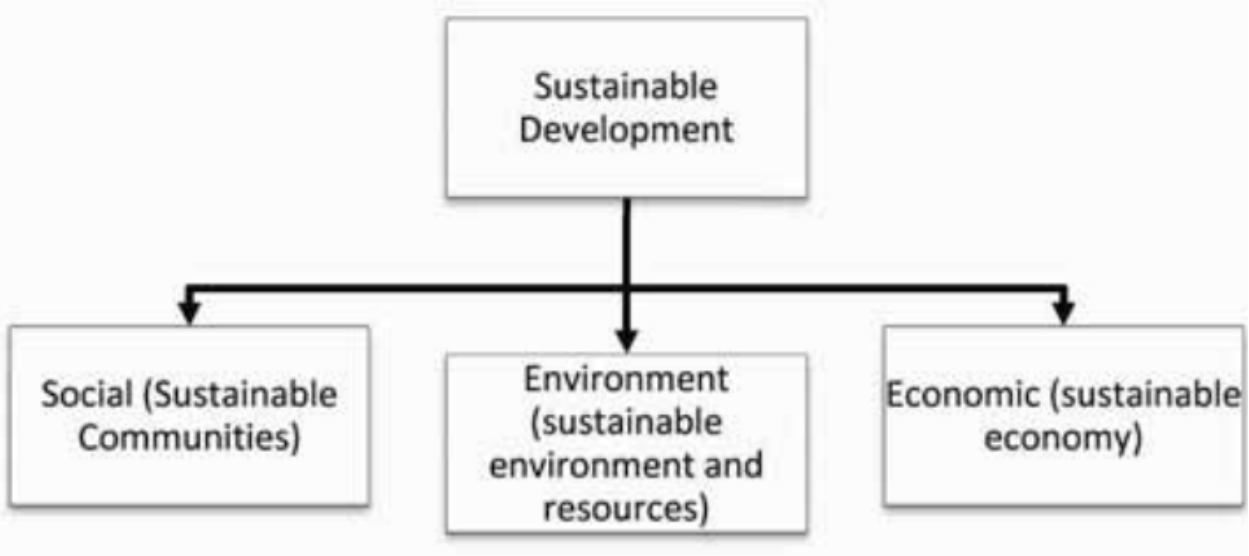

Figure 2.2- Pillars of the sustainable development approach

Agenda 21, Rio Conference on Sustainable Development 1992 identified the environment, social development, and economic development as the cornerstones of sustainable development. The conference emphasized the need to integrate and balance the three cornerstones (Figure 2.2). The UK Government Uses the Sustainable Development Commission which evaluates sustainable development based on 15 different sustainable development indicators they are economic output; investment; employment; poverty and social exclusion; education; health; housing; crime; climate change; air quality; road traffic; river water quality; wildlife; land use; waste.

The conventional approach to road construction doesn't satisfy the issues under the different themes of sustainable development. The conventional road construction approach doesn't consider the social inclusion of the people. A sustainable approach should be one which considered the wider socio-economic condition of the place where infrastructure is developed. A sustainable road project aims to reduce rural poverty in rural areas by extending the network of rural transport infrastructure and more importantly employing the community, empowering them, increasing the institutional capacity building, and improving the sense of accountability and transparency. The sustainable approach is the one which moves a step forward beyond developing only basic infrastructure. It is essential to adopt the appropriate technology based on the need of people and the stage of development.

In this study, the researcher tried to indicate some aspects of sustainable roads based on themes of sustainable development and internationally accepted sustainable development indicators to

define sustainable roads as a sustainable approach for developing countries like Ethiopia. The principles, implementing procedures, and outputs of the sustainable road project are important verifiable indicators.

2.9.1. Environment Sustainability

One of the important aspects of Sustainability is the protection of the environment. The sustainable road concept is based on an environmentally friendly approach.(Das Mulmi, 2009)

2.9.1.1. Minimization of slope cutting and preservation of the vegetative cover

The conventional road construction practice of developing the road width by full cutting and throwing the excavated material downhill is a waste of valuable mass and can cause damage to the vegetative cover. Instead, a proper cut-and-mill method of mass balancing is used in the sustainable road approach, the excavated materials are used for filling the valley side by constructing a toe wall. Similarly, the trees along the alignment are not cut till the road is in operation. Suitable plants are collected and assessed for bioengineering purposes. (Das Mulmi, 2009)

2.9.1.2. Environment-Friendly Construction methods

The construction of the sustainable road considered the environment in the best possible ways. the sustainable road is constructed in phases to conserve the fragile mountain slope by minimizing the risk of landslide and soil erosion. Similarly, critical sections are identified and relevant adjustment is made. The phase-wise construction (Table 2) helps in assessing the local natural resources for utilization in the construction phase. Construction material availability survey and Plant availability survey are done to assess the availability of local resources and plants respectively.

Blasting which is frequently used in conventional approaches is not allowed in sustainable road approaches. Instead, a simple methods like Chiseling and Hammering, Heating and Breaking, and Drilling are done to cut the rocks. The Local people employed during the construction works can easily use these simple tools and pieces of equipment. The approach did not use dozers, excavators, and other heavy equipment which consume an extensive amount of fuel in the construction works hence there is no emission of greenhouse gases. The construction methods are environment friendly as it approaches use labor-intensive techniques that result in almost zero carbon dioxide emission during the construction of the road.(Das Mulmi, 2009)

2.9.1.3. Environment appraisal

As mentioned earlier, careless planning and rapid engineering lead to adverse environmental consequences in the form of slope stability, spoil disposal, water management, and vegetation cover. The sustainable road concept promotes mitigation measures to reduce negative environmental impacts. The use of substantial bioengineering measures and awareness raising among the communities of the consequences of environmental adversities are part of the mitigation measures. More importantly, environmental appraisal has been an important part of sustainable roads. (Sarkar, 2011)

An environmental Impact Assessment (EIA) study was performed to assess the likely impact on the environment and to offer recommendations to make the road environmentally and socially sound and sustainable. The EIA report is quite broad and covers various aspects of the physical, biological, and socio-cultural-economic environments. It forms a legal obligation under the Environment Protection Act 1998. The EIA includes documentation of environmental baseline information of the project influence area, analysis of positive and negative impacts, recommendation of appropriate preventive and curative measures, and environmental and social management plan to implement the mitigation measures.

Bioengineering is the use of living plants to reduce slope instability and soil erosion. The green road approach incorporates bioengineering as one of the important tools of environment conservation. Bioengineering is used as a preventive measure rather than a curative one. Local people having their indigenous skills are encouraged for the plantation works and establish the nurseries by providing the appropriate technical advice and support. A plant availability survey was conducted simultaneously with the road alignment survey in the beginning. The local communities and farmers and landowners in the road corridors were included in the bioengineering process, to make it effective and sustainable as well as income-generating. (Das Mulmi, 2009)

2.9.2. Sustainable Communities

One of the important aspects of Sustainability is sustainable communities. The following listed the major socially inclusive indicators of sustainable roads which prove the approach is socially sustainable.

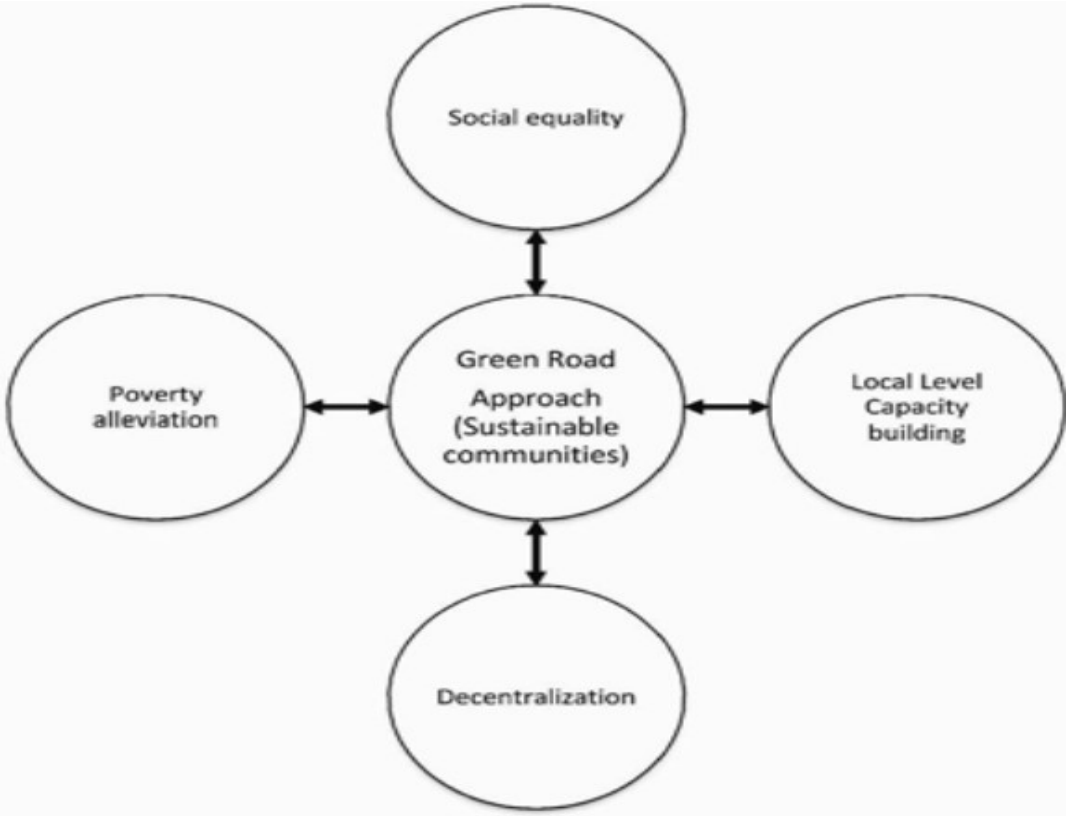

Figure 2.3 sustainable road approach for sustainable communities

2.9.2.1. Decentralization and participatory approach

The approach adopts the decentralization strategy throughout the process of the project cycle. The Sustainable Road approach uses the participatory involvement of local authorities and stakeholder communities throughout the formulation, planning, construction, and maintenance phases to promote a sense of local road ownership for its operation and maintenance. The beneficiaries make the decisions on the selection of the project, road alignment, labor management, User group formation, and resource distribution and utilization.(Gyadu-Asiedu et al., 2021)

2.9.2.2. Social equality and gender balance

The 1996 NLSS shows that income poverty incidence is correlated with caste/ethnicity, education, and land ownership. In general, the occupational caste group (Kami, Damai, Sarki -- traditionally considered the 'untouchables') have a significantly high poverty incidence compared to the 'higher caste' group. Household heads who are either illiterate or have only primary education have the highest incidence of poverty and those with above secondary education have

the lowest incidence. Similarly, the incidence of poverty has, in general, an inverse relationship with the amount of land holding. (Lombard & Coetzer, n.d.2018). Social conflicts arise because of social disparity. The advantaged group has the competitive advantage in the form of knowledge and control of resources over the disadvantaged group (DAG), ethnic minorities, and indigenous populations because of education, access to infrastructure, and access to knowledge and property. And because of that DAG group is the poorest among the communities. The sustainable road approach emphasizes the good participation of the low caste and disadvantaged groups. The approach addresses the social inequalities that are the root cause of the conflict.

Likewise, Gender equality is the principal aspect of the sustainable road concept to promote women's participation in all the intervention areas. The project provides equal opportunities for men and women; improved the integration of women into the decision-making process; and enhanced the gender sensitivity of stakeholders in intervention areas. The women are not confined within the boundary of the house they are actively participating in the construction work. The women received the same wages for similar types of and the same quantity of work as men.

2.9.3. Sustainable Economy

Another important aspect of Sustainability is the sustainable economy. The following listed the major economic indicators of sustainable roads which prove the sustainable road approach economically sustainable.

2.9.3.1. Sustainable economic development

Creation of the employment opportunities has been the major objective of development planning in recent days. The sustainable road concept not only brings off-farm employment to a large number of people but the mechanism development within the sustainable road concept projects contributes to the country's economic growth. The mechanism promotes local savings which provides them to involve in the enterprises and income development activities. The savings made by them provide the basis for further investment, so the sustainable road concept promotes the sustainable economic cycle (Bekele Kilisa, 2021).

2.9.3.2. Optimum utilization of local resources

Optimum utilization of local resources is one of the important indicators of sustainable development. sustainable road concept encourages the optimum uses of local resources in the

form of local labor, local materials, and local finance. Suitable construction techniques (such as soft structures, etc.) are applied by using mainly local construction materials (excavated stone, chips, soil, plants, etc.) and locally produced tools and low-cost intermediate equipment where possible (i.e. suitable wheelbarrows and appropriate drilling equipment, etc.). Since off-farm employment opportunities are very rare in rural areas, labor-intensive road construction methods (mainly manual work) are adopted rather than capital-intensive technologies (such as bulldozers) to generate local employment opportunities and to recycle financial resources at the local level as "poverty alleviation" measure. A re-utilization of locally available natural resources obtained from the excavation is strongly utilized in the construction process. This form of re-utilization of material is economic and environment-friendly. Excavated soil, rocks, topsoil, and vegetation are the primary construction materials for sustainable Roads. Excavated soil can be used in the filling works for mass balancing as well as for widening the roads at the passing bays and switchbacks. Likewise, the stone obtained during the construction works is stacked along the road so that it can be reused for the construction of dry-stone masonry, gabion walls, and water management structure. Vegetation and topsoil can be used for turf and re-vegetation of the hill slopes. Local indigenous skills and knowledge are optimally utilized which makes the road construction not only cheaper but also maintainable. Flexible structures like dry stone and gabions are preferred over masonry or concrete structures to utilize the local materials, and skills and to promote local workmanship.(Montgomery et al., 2015)

2.9.3.3. Foreign Exchange Control

Steel, Cement, fuels, heavy equipment, and machinery are part of the industrial goods which need to be imported for construction works. Like in many hydropower projects, large numbers of capital goods are imported in the form of turbines, equipment setup, and others. Hence, a high percentage of the money attributed by international agencies (either loan or grant) returns immediately back into the industrial world. Road construction using sustainable road construction relies on the optimal utilization of the local resources hence it contributes to maintaining the foreign exchange reserve of the country (Garg & Yadav, n.d.2020)

2.9.3.4. Cost reduction

Heavy equipment is expensive to mobilize, difficult to deploy on-site without the excessive environmental damage, and subject to excessive downtime due to the delay in obtaining spares and fuel from the capital.

2.10. Benefits of Adopting Sustainable Construction

It is a consensus that the benefits of adopting sustainable construction outweigh those of not adopting it (Waidyasekara & Fernando, 2012: 7). However, the key benefits of its adoption are not global, because they are mostly country and region-specific. Many studies investigated the benefits of sustainable construction as they relate to their local economies. In addition, the benefits investigated were mostly lumped rather than categorized into their constituent economic, social, and environmental benefits for easy analysis and understanding. Hence, this study investigates the benefits of sustainable construction based on economic, social, and environmental factors.

The main environmental benefit of sustainable construction is the protection of the ecosystem. This can easily be ensured by incorporating components of landscaping or by sourcing specialist ecologists to determine the specific needs of an area, initiate suitable management techniques, reduce activities that result in loss of habitat, and use species that should be planted in landscaped areas (Ametepey *et al*., 2015: 1687). Reduced carbon emissions that prevent global warming and extreme climate change were also described as environmental benefits of sustainable construction (Vazquez, Rola, Martins, Freitas & Rosa, 2011: 271; Simpeh & Smallwood, 2018: 1845). Environmental benefits of sustainable construction also include the minimization of wastage through recycling, reusing, and reducing waste streams and the conservation of water through the water supply, water consumption, and wastewater systems (Ametepey *et al*., 2015: 1688).

Out of 19 environmental benefits investigated by Waidyasekara and Fernando (2012: 10) in Sri Lanka, the better air quality inside the facility, reduced energy use, lower fossil fuel use, and the protection of ecological resources were identified as the top four environmental beneficial factors. Lower resource use was the least beneficial. Simple and Smallwood (2018: 1844) noted that improved air and water quality, reduced waste, conservation, and restoration of natural resources protect biodiversity and ecosystems, and reduce heat gain, particularly when buildings are designed and oriented to optimize the utilization of daylight.

(Mustafa et al., 2022a) summarized the environmental benefits of sustainable construction as the reduction of greenhouse gas emissions through reduced energy consumption, reduction of air pollution, reduction of solid waste generation through the creation of space for storage and collection of recyclable waste materials, waste management practices on sites, and modular construction techniques, space utilization in the form of erosion and sedimentation control, reduced lighting disturbances, reduced use of water, and decreased use of fossil and nuclear fuels. Lower potable water use, the better air quality inside the facility, reduced energy use, lower fossil fuel use, protection of ecological resources, lower pollution discharges to waterways, reduced air pollution, soil, and water conservation, less carbon dioxide emissions, increase in the local recycling market, land preservation, and decreased impact of fossil fuel production and distribution were described as the environmental benefits of sustainable construction (Bekele Kilisa, 2021)

(Danso et al., 2013) noted that the economic benefits of sustainable construction can also be called financial benefits. However, they also noted concerns about the availability of information on the full benefits of sustainable construction in the South African construction industry. Simple and Smallwood (2018: 1845) noted that the economic benefits of sustainable construction are lower operating costs, expansion of markets for sustainable construction, enhancement of occupants' productivity, and optimization of economic performance beyond the lifetime of a building. Economic benefits can also be regarded as direct benefits, as manifested in energy and water consumption (Belachew et al., 2017).

According to (Of et al., 2015) the economic benefits of sustainable construction are inherent in the integration of green principles into a building's design process. This can lead to roughly 40% further savings and 40% better performance than simply adding green technologies to traditionally designed facilities. Other benefits linked with sustainable construction are reduced energy costs, reduced employee health problems, and increased productivity. (Engineering et al., n.d.) identified lower energy costs, lower annual electricity costs, reduced annual water costs and wastewater costs, as well as lower annual fuel costs as economic benefits.

Similar to the other types of benefits, the social benefits of sustainable construction have hardly been discussed in the literature, thus making it a herculean task to differentiate the categories to which each of the benefits belongs. (Chamorro Giné, 2012) tried to discuss the meaning of the social benefits of sustainable construction but failed to itemize the benefits. It was pointed out

that a sustainable construction project is not only defined by its environmental, economic, and social benefits but also by its construction process (Iimi et al., 2015). (Mustafa et al., 2022a), however, noted that enhanced comfort, job creation, occupants' health, and aesthetics are some of the social benefits of sustainable construction. Preservation of water resources expanded the market for environmentally preferable products, reduced adverse health impacts, improved occupant satisfaction and comfort, and increased transportation options for employees, and better occupant comfort satisfaction (Belachew et al., 2017).

Uncategorized benefits of sustainable construction are opportunities for research and development in the construction industry, more tax revenue for the government, climate change-related benefits, reduction of carbon emission, reduction in water and wastewater pumping, as well as reductions in the use of energy. Others include reduction in pollution and environmental degradation, energy efficiency and water conservation, improved indoor air and water quality, protection of biodiversity and ecosystems, the minimized strain on local infrastructure, protection of health and comfort, improved quality of life, giving a benchmark for future construction, facilitating a culture of best practice sharing, reduced operational cost, improved occupants' productivity, and reduced utility cost (Belachew et al., 2017).

According to (Asomani-Boateng et al., 2015), the benefits of sustainable construction are cost-effectiveness, environmentally friendly, natural resources-based, durable, construction of healthy habitat for the occupants, preserved livestock, controlled use of resources, reduced dependency, pollution control, and better growth/yield. The Commission for Environmental Cooperation (2008: 65) noted that, in North America, the benefits of green building were estimated by the USGBC to be to reduce energy consumption by 30%, carbon emissions by 35%, water consumption by 30%-50%, and generate waste cost savings of 50%-90%. Sustainable construction promotes stronger societies and provides important benefits to human health and productivity.

Heilman (2016: 134) noted that the many benefits of sustainable construction need to be defined, strategized, and identified. This was buttressed by Rahim, Yusoff, Zainon, Wang, and Lumpur (2014: 89) who stated that sustainable construction has many benefits, including operational savings, improved use of construction resources, and increased workplace productivity. (Lombeso & Berhanu, 2018) traced the benefits of sustainable construction to reduced energy costs, improved employee health, and productivity, boosted company image, and a more pleasant

workplace. In the real estate field, sustainable construction gives higher building value, productivity, cost savings, and environmental gains (Chamorro Giné, 2012). Given these, the importance of clarifying the benefits associated with the South African construction industry cannot be overemphasized if its gains are to be maximized.

2.11. Factors Influencing the Adoption of Sustainable Road Construction Concepts

Sustainable construction is being adopted and is on the increase. However, its current rate of adoption appears not to be on par with the rate of the negative impact of construction activities on the environment. Many factors have been advanced as being responsible for the reluctance and slow adoption of sustainable construction. The cost of sustainable construction has reduced over time, but it is still more expensive than traditional building methods. Depending on the green features and materials to be used, the recovery period can be relatively short or long (Chamorro Giné, 2012). Acquiring green accreditation could also be cost-intensive, time-consuming, and stressful, regardless of its potential to increase property rental value (Program et al., 1982). In addition, the availability and accessibility of sustainable materials and expertise, with sufficient knowledge of sustainable construction, is a key factor to be (Gyadu-Asiedu et al., 2021; Program et al., 1982). The surroundings of the proposed building site become another factor that is worth considering. Trees and other buildings could obstruct sunlight, thus decreasing the output of solar systems. Other factors that influence the adoption of sustainable construction include financial and further market-based incentives for sustainability adopters, governmental policies and regulations, and stakeholder participation (Gómez-Cabrera et al., 2020).

am, Chan, Poon, Chau, and Chun (2010: 657) classified twenty factors that influence the adoption of sustainable construction into stakeholder involvement, leadership, responsibility, principles, and techniques, as well as feedback and building public confidence(Suprayoga et al., 2020) categorized the factors that influence sustainable construction into management, motivating factors, internal resources, external factors, readiness to adopt sustainable construction, supporting resources, and current practices. (Suprayoga et al., 2020) highlighted the following: scope and quality of the input of resources, flexibility of design changes to maintenance and variation, estimation of the cost of design and construction, unforeseen inflation in the process of materials for sustainable projects, and the management of the size and complexity of sustainable projects. (Singru, 2009a) classified thirteen factors into internal and

external factors that influence the adoption of sustainable construction. Kheni and Akoogo (2015: 70) affirmed that the following factors influence the adoption of sustainable construction: awareness of the concept, its relative advantage in business and project use, its compatibility with the client and organizational goals, the complexity of sustainable construction projects, the feasibility of adopting sustainable construction, and the influence of peer companies on a company. (Mustafa et al., 2022b) investigated the various factors of sustainable construction, as identified in the literature, and classified them into three cardinal categories of economic, social, and environmental factors. Economic factors contain 23 variables that were further divided into cost efficiency, affordability of the project, sustainable construction with minimum cost option, and job creation within the local economy. Social factors include the indoor environmental quality of projects, the safety of the people and environment, social and recreational amenities in a building and the community, accessibility to jobs, and amenities by occupants of sustainable projects. Environmental factors include energy generation and consumption, amount of greenhouse carbon emission, water use, efficiency, and conservation, material use and efficiency, use of construction land space, waste management, protection and promotion of biodiversity, level of noise and air pollution, and level of dependence on a personal car. (Singru, 2009b) categorized the factors of sustainable construction into economic factors (stakeholders' demand and financial issues) and ecological/social responsibility factors (environmental and social responsibility). The results of the study indicated that the key factors of sustainable construction are the industry's Green Star rating system, rising energy costs, legislation, and competitive advantages. Sustainable construction includes ten economic factors, ten political factors, ten social factors, ten technological factors, and ten ecological factors .

2.12. Challenges of Sustainable Construction

Sustainable construction also has inherent challenges that hamper its effective adoption. (Kehagia, 2009) identified financial constraints, inadequate proactive plans, inefficient technology, an insufficient commitment of upper-level management, insufficient environmental competencies, lack of awareness among stakeholders, lack of sustainable waste management, lack of workers' training in sustainable operations, management's unwillingness, political impacts, and preferences of suppliers/institutional buyers as the barriers to the effective adoption of sustainable construction in the United States. In Nelson Mandela Bay, it was noted that perceived increased upfront costs, high material costs, minimum standard requirements, and lack

of specialist knowledge are the main barriers to the full uptake of sustainable construction (Kehagia, 2009)

The Commission for Environmental Cooperation (Basiago, 1451a) advanced the following barriers: separate capital and operating budgets, split incentives, higher perceived/actual first costs, risks and uncertainties, lack of experienced workforce, lack of coordination and consistency in government policies, lack of investment in research, and issues specific to the region. Simple and Smallwood (2015: 96) identified the following barriers: capacity barriers, cultural and social resistances, lack of incentives to promote sustainable building, inadequate cost data for sustainable buildings, inadequate information regarding the financial and economic benefits and opportunities of sustainable buildings, limited range of sustainable materials, and delays in obtaining certifications and permits for sustainable buildings.

Among the highly ranked barriers to sustainable construction is poor sustainability education in academic institutions, lack of incentives for designers, ignorance of life-cycle cost benefits, sustainable construction being less prioritized and other issues taking priority, as well as resistance to cultural change in the industry (Suprayoga et al., 2020). The challenges of sustainable construction were classified into external and internal challenges (Chamorro Giné, 2012). Hayles and (Gómez-Cabrera et al., 2020) noted that, in Australia, lack of accurate data, poverty, low urban investment, stakeholders' lack of interest in sustainability, technological inertia, and dependency, lack of integrated research, and entrenched colonial codes and standards, lack of knowledge and information on sustainable construction, as well as lack of affordable solutions are major obstacles of sustainable construction. In developing countries such as South Africa, poverty and lack of technologies and materials are the key barriers to sustainable construction.

sustainable road contributes to the roadway systems' sustainability since its object and criteria can improve 'natural laws' and 'human values' (Ekung, 2017) The goals of sustainable road construction are to protect and enhance the quality of the ecosystem, environment, and resource efficiency (Sarkar, 2011). However, the implementation of green construction on highway projects faces many challenges related to materials, equipment, codes and standards, financial issues, regulations, and culture (Chamorro Giné, 2012).

According to Manley et al. (2009), the major drivers of adoption are the firm's enterprise competencies and the outside environment, or macro context. (Sarkar, 2011) also claimed that an

invention's effective adoption depends on several elements, including human-related, project-related, and management-related aspects and external environment-related factors. The authors also claimed that adoption requires a broader understanding of the primary critical concerns to be adopted and implemented in the context of the construction business. In examining important success elements for sustainable construction projects, (Chamorro Giné, 2012) identified and associated critical success criteria for sustainable construction projects with the following stakeholders, owners, designers, contractors, localities, and government. The authors found that more vital factors were associated with the contractors and the owners, reflecting their level of influence in the successful delivery of sustainable building projects. Some factors identified include efficient project planning and control; worker's experience; awareness and skill level education and training; dedicated department for sustainability; communication and cooperation between project participants; active stakeholder involvement; construction of sustainable culture; top management support; clear goals and objectives; reliability of specifications guide and benchmarking systems; broad community support; end-user involvement among others.

A major factor in adopting sustainable construction concepts in road construction is the availability of financial support and funding for green road projects (Gyadu-Asiedu et al., 2021). Similarly, (Kehagia, 2009) believed that implementing green concepts in road construction largely relies on providing financial support. (Chamorro Giné, 2012) explained the drivers for adopting sustainability content into road infrastructure projects. First, a platform for dialogue and cooperation between industry and academia on sustainable roads; establishing appropriate work ethics for workers; considering sustainable criteria for procurement as a priority; and allocating resources to enable sustainable road infrastructure development. According to (Gyadu-Asiedu et al., 2021), the enablers of the implementation of sustainable construction methods in road infrastructure development are a collaboration among key stakeholders such as government, consultants, and suppliers to develop a reliable and accessible database of green road specifications; effective government policies toward sustainable construction; the use of sustainability requirements in tender evaluation criteria; and putting in place whole-life costing. According to (Basiago, 1451a) implementing sustainable construction practices in the road sector is driven by incorporating sustainability consciousness into road construction professionals and adequate training of human resources on green road concepts. (Yang et al., 2018) observed that effective collaboration, communication, and information sharing among stakeholders, and the

development of standards and codes for green road implementation are key issues driving sustainability principles in road infrastructure development. Raising awareness of sustainability issues can potentially drive the acceptance and implementation of sustainable tenets in road construction (Basiago, 1451b). According to (Mary' & Seife, 2019), developing a supporting infrastructure for successfully adopting sustainable roads is key to adopting sustainability principles in road construction. Adequate education of personnel on green road concepts was viewed by (Of et al., 2015) as key to adopting green principles in the road sector.

CHAPTER THREE

3. RESEARCH METHODOLOGY

3.1. Introduction

This section presents the methodologies adopted for the study in the process of collecting data both from questionaries surveys and interviews, analyzing and interpreting information to provide solutions to questions. The scope of the research is limited to rural road construction in West Arsi Zone, Oromia regional state. It is intended to gather facts based on research problems initiated mainly from observations and the experience of the researcher. Information includes primary and secondary data sources from selected ongoing and completed rural road projects of West Arsi Zone, Oromia regional state.

3.2. Study Area Description

West Arsi Zone is located approximately at a distance of 251km from Addis Ababa. It is located in the Rift Valley Region. The zone extends from 6012'29" to 7042'55" latitude and 38004'04" to 39046'08" longitude. It shares a bounder line with the East Shewa zone to the north, SNNPRS to the west, Arsi to the northeast, Guji to the south, and Bale zone to the east. Most parts of the zone have elevations ranging from 1500 to over 2300m. Shashemene town is the administrative center of the zone. The total length of the boundary line is about 174km. Shashemene is the capital town of the zone. It is located 251km from Addis Ababa. Having a total area of 12409.99 km2.

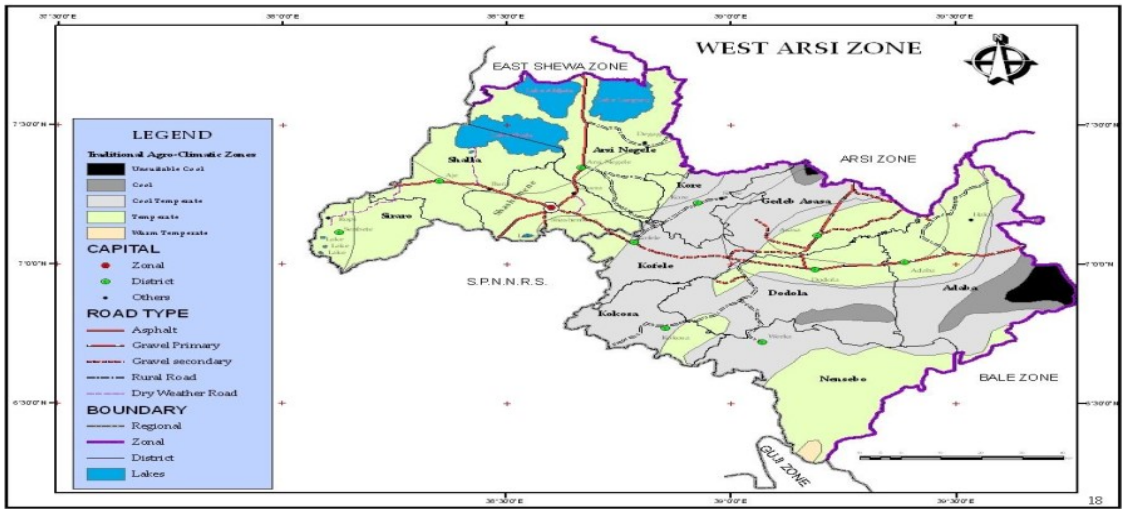

Figure 3.2- West Arsi zone map (Google map accessed on May 25, 2023).

3.3. Research Design

This research aims to explore the sustainability of rural road construction approaches in the West Arsi Zone. To achieve the objective of the study it was applied mixed research approach (both qualitative and quantitative). The intent of using this design is to bring together the differing strengths and nonoverlapping weaknesses of quantitative methods with those of qualitative methods (Creswell and Creswell 2003). The quantitative survey research technique used a closed-ended questionnaire because of its ability to allow the researchers to generalize their findings from the sample frame (Bryman, 2012: 232). it also allows for descriptive and inferential statical data analysis. On the other hand, it was a qualitative approach because it can describe the using texts about the sustainability of rural road construction and barriers to the adoption of sustainable rural road construction in the case of West Arsi Zone of Oromia regional state.

The need to take up a descriptive study is because of its ability to ensure a complete description of the situation, making sure that there is minimum bias in the collection of data and reducing errors in interpreting the data collected.

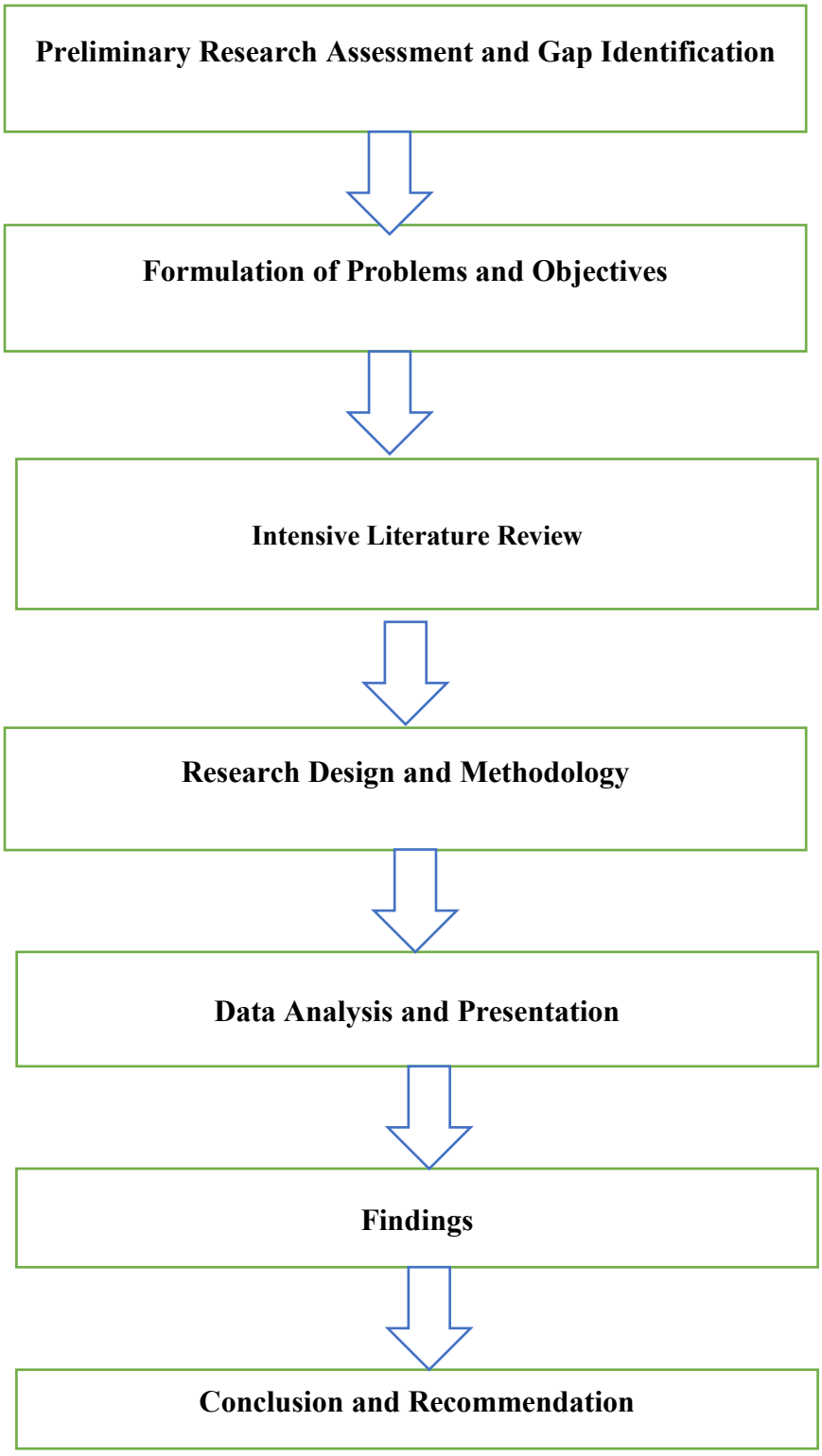

Figure 3.2- Research Design

3.4. Population

Sustainable construction is not only a national subject, but it is also global. However, for effectiveness, the study was conducted in the West Arsi Zone of the Oromia regional state, Ethiopia. West Arsi zone was selected for the study.

The population of the study comprised the client, construction (contractors and consultants) organization, and displaced households those lives in the area of rural road construction projects in West Arsi Zone of Oromia regional state, hence the population of the study were totally 200(Two Hundred) which constitutes General contractors and Road contractors. The respondents for the study were the professionals (construction managers, quantity surveyors, engineers, and architects) in the construction firms that were used for the study.

3.5. Sample Size

It is necessary to select a sample size that will give an estimated mean within acceptable error limits. Statistical procedures are used to determine this minimum sample size. The properties of the normal distribution have been used to develop an equation relating the sample size to the number of standard variations corresponding to a particular confidence level, the limits of tolerable error, and the standard deviation. The formula is;

$$\mathbf{N} = \left\{\frac{z*\sigma}{d}\right\}^2 \quad \text{……………………………………………………………………………}\textit{Equation 1}$$

Where;

- *N* denotes minimum sample size
- *Z* denotes number of standard deviations corresponding to the required level of confidence
- σ denotes standard deviation.
- *d* denotes limit of acceptable error in the average (Gyadu-Asiedu et al., 2021).

Using equation 1, z= 1.96 for 95% confidence level, σ= 1.2, which is standard deviation and d= 0.35, which is average limit of acceptable error, substituting this it gives minimum sample size of 46, so 50 sample size were taken.

3.6. Sampling Technique

The objective of sampling was to provide a practical means of enabling the data collection and processing components of research to be carried out whilst ensuring that the sample provides a good representation of the population; that is the sample was representative. (Richard Fellows and Anita Liu, December 2007), since complete information about the population is available systematic sampling was used as the sampling technique of the research to extract the sample easily and to ensure cases are spread across the population.

3.7. Data Sources and Types

Primary data was collected directly from a questionnaire survey and interview. Secondary data was also second-hand information from previous studies and books. The researcher also use secondary sources to have some background information about the issues related to the documents that were analyzed. Documents like magazines, books, journals, and research papers, published and unpublished materials were examined not only to help to establish the review of related literature but also to come up with sufficient information about the issue.

3.8. Data Collection Methods

Data was collected through a data collection instrument. As mentioned before, the data sources have been both primary and secondary. The following is a brief description of data-gathering instruments.

The investigator was conducted through a questionnaire (close-ended), and interview (structured and unstructured) for the collection of primary data sources. The following is a brief explanation of how the primary data was collected.

A. The questionnaire for the study was delivered by hand to selected clients, contractors, and households and collected at a later earlier possible date. Some contractors and clients received and completed their questionnaires in Google form. The questionnaire consisted of five sections. The first section, on the respondent's demographic profile, obtained personal information on age, profession/area of specialization, work experience, academic qualification, and sector of work. The second section set 36 Likert-scale statements for the assessment of sustainable rural road construction; the third section set 12 Likert-scale statements to identify factors influencing the adoption of sustainable rural road construction. In the fourth section, 16 Likert scale items construct in this case the respondents are

requested to rate the level of importance of each benefit of sustainable rural road construction. Section five set 21 Likert-scale items on the construct "barriers" of sustainable rural road construction Respondents were requested to rate the level of importance of each statement in hindering the use of sustainable rural road construction systems.

The data from these measurements form the Likert-scale items used in the descriptive and inferential analysis of this study. To reduce the respondents' bias, closed-ended questions were preferred for sections two to four (Akintoye & Main, 2007: 601).

B. Interview: In-depth interview was employed in collecting detailed data which is a complete picture of the objectives of this study from randomly selected respondents. The researchers selected those participants assuming that they have an experience with issues under study and can provide pertinent information.

3.9. Data Analysis and Interpretation Techniques

The data for the study was analyzed, using the Statistical Package for Social Sciences, version 20. The result of the study was presented with frequencies, percentages, mean scores, interpretation of mean scores, and ranks. The respondents' information was analyzed, using descriptive statistics such as frequencies and percentages. The factors influencing, benefits, and barriers of sustainable rural road construction were analyzed using mean scores, interpretation of mean scores, and ranks.

The rural road sustainability assessment was analyzed, based on the scale measurements 1= strongly disagree (≥1.00 and ≤1.49); 2 = disagree (≥1.50 and ≤2.49); 3 = neutral (≥2.50 and ≤3.49); 4 = agree (≥3.50 and ≤4.49) and 5= strongly agree (≥4.50 and ≤5.00). The factors influencing and the barriers to sustainable construction were analyzed, based on the following scale measurements: 1 = Not significant (≥1.00 and ≤1.49); 2 = Slightly significant (≥1.50 and ≤2.49); 3 = Averagely significant (≥2.50 and ≤3.49); 4 = Significant (≥3.50 and ≤4.49), and 5 = Very significant (≥4.50 and ≤5.00). The benefits of sustainable construction were analyzed, based on 1 = Not important (≥1.00 and ≤1.49); 2 = Slightly important (≥1.50 and ≤2.49); 3 = Averagely important (≥2.50 and ≤3.49); 4 = Important (≥3.50 and ≤4.49), and 5 = Very important (≥4.50 and ≤5.00).

3.10. Instrument Validity and Reliability

3.10.1. Instrument Validity

Validity refers to the degree to which the findings of data analysis accurately reflect the phenomenon under investigation. Validity is a function of degree rather than absolute value. Until conducting the final process, a pilot study was conducted to refine the approach and test instrument, which is a questionnaire, in order to ensure instrument validity. Questionnaires were tested on 3 respondents in determining the internal reliability of the factors influencing, benefits, and barriers of sustainable construction.

3.10.2. Instrument Reliability

Reliability refers to the extent to which an instrument consistently measures what is supposed to. The study measured the internal consistency of cross-sectional data collection instrument, i.e., questionnaire, using Cronbach alpha coefficient.

The Cronbach alpha coefficient, which is based on the average correlation among items, was calculated for the 4 main Constructs using SPSS software and the result is presented in the following table:

Table 3.6.2: Cronbach alpha values for main constructs

Constructs	**Cronbach Alpha (α)**	**A rule of thumb for interpreting alpha for Likert scale items**
Sustainability of rural road construction	0.78	**Acceptable**
Factors influencing the adoption of sustainable rural road construction	0.95	**Excellent**
Benefits of sustainable rural road construction	0.90	**Excellent**
Barriers to the adoption of sustainable rural road construction	0.88	Good

- **A rule of thumb for interpreting alpha for Likert scale items**

If Cronbach's Alpha is ≥0.9, the internal consistency of scale is Excellent.

If Cronbach's Alpha is 0.90>α≥0.80, the internal consistency of scale is Good.

If Cronbach's Alpha is 0.80>α≥0.70, the internal consistency of scale is Acceptable.

If Cronbach's Alpha is 0.70>α≥0.60, the internal consistency of scale is Questionable.

If Cronbach's Alpha is 0.60>α≥0.50, the internal consistency of scale is Poor.

If Cronbach's Alpha is 0.50>α, the internal consistency of scale is Unacceptable.

3.11. Ethical Considerations

Every respondent has had the right to determine whether or not to participate in the research project. The information provided from the questionnaire was kept private and the respondents were assured that the information they provide is confidential and used for academic purpose only.

In addition, all sources cited in this study have been duly acknowledged.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1. Introduction

In this section the findings from the questionnaires are analyzed, interpreted and discussed. The data found is organized and analyzed in to four sections so as to answer the research questions raised and meet the objectives of the study. Where the first section presents the respondents profile by years of professional experience and job title. The second section analyses the sustainability of rural road construction in case of West Arsi Zone Oromia reginal state. The third section analyzes factors influencing the adoption of sustainable rural road construction in case of Wast Arsi Zone of Oromia regional state. The fourth section analyzes the

- To examine the sustainability of rural road construction in the case of West Arsi Zone, Oromia regional state.
- To identify the factors influencing the adoption of sustainable rural road construction in the case of West Arsi zone, Oromia regional state.
- To investigate the benefits of sustainable rural road construction based on economic, social, and environmental factors in the case of West Arsi Zone of Oromia regional state.
- To examines barriers to the adoption of sustainable rural road construction in the case of West Arsi Zone of Oromia regional state.

4.2. Respondents' Profile

Table 1 shows that general information of respondents of the study. The data collected from the survey indicated that the majority (60%) of the respondents are construction/project managers or architects (26%) and 14% quantity surveyor. Analysis of respondent's academic qualification showed that the majority of the respondents have bachelor degree (58%), 22% Masters degree and 20% diploma. And over 66% of the respondents were have 6 to 10 years' experience, and 20% of the respondents have 11 to 15 and the remain 12 % of the respondents have below five years and above 20 years of experience.

Table 4.1- Respondents Profession/Job Title

Profession	Frequency	percent	Valid percent	Cumulative percent
Architect	13	26.0	26.0	26.0
Construction/project Manager	30	60.0	60.0	86.0
Quantity Surveyor	7	14.0	14.0	100.0
Total	50	100.0	100.0	

Table 4.2- Respondent Academic Qualification

Qualification	Frequency	percent	Valid percent	Cumulative percent
Diploma	10	20	20	20
Bachelor's Degree	29	58	58	78
Master's Degree	11	22	22	100
Total	50	100	100	

Table 4.3- Respondent Professional Experience

Experience	Frequency	percent	Valid percent	Cumulative percent
Below 5 years	3	6	6	6
6-10	33	66	66	72
11-15	10	20	20	92
16-20	3	6	6	98
Over 20	1	2	2	100
Total	50	100	100	

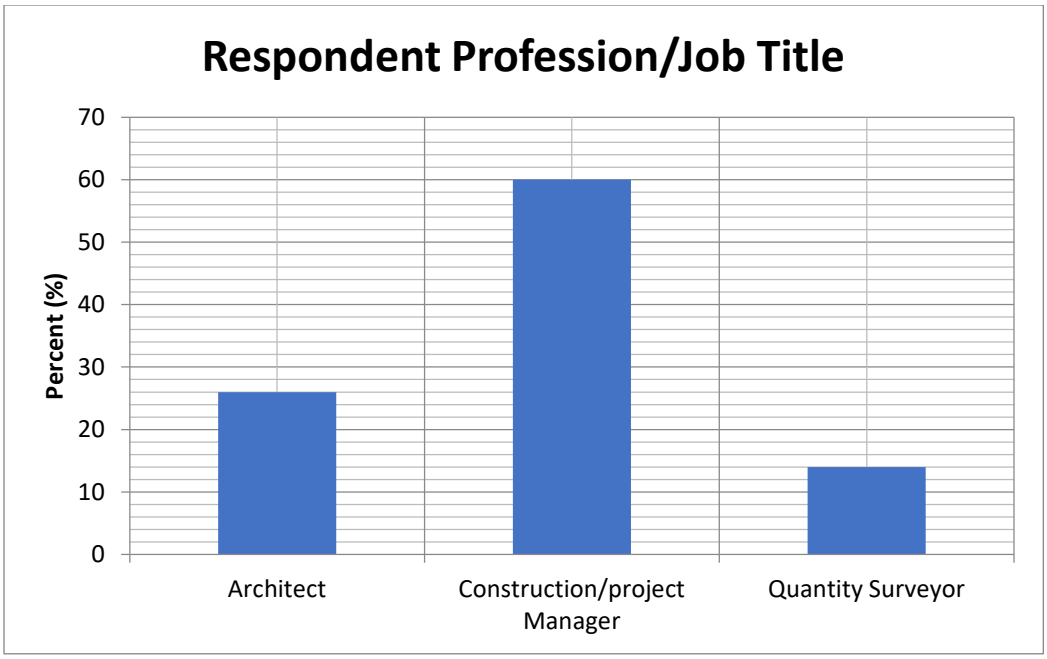

Figure 4.1- Respondent Profession/Job Title

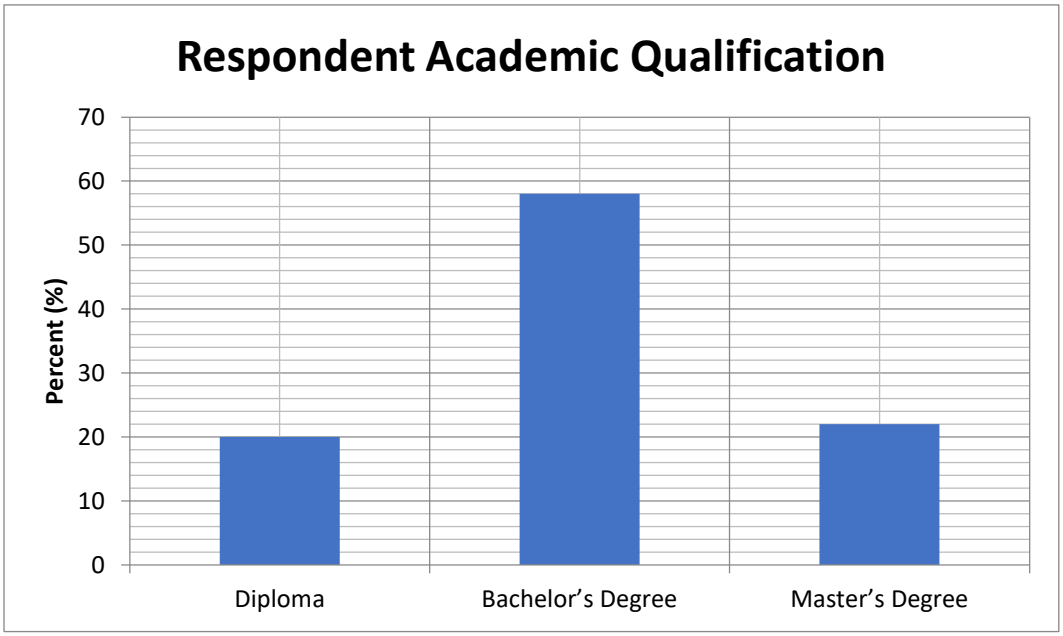

Figure 4.2- Respondents Academic Qualification

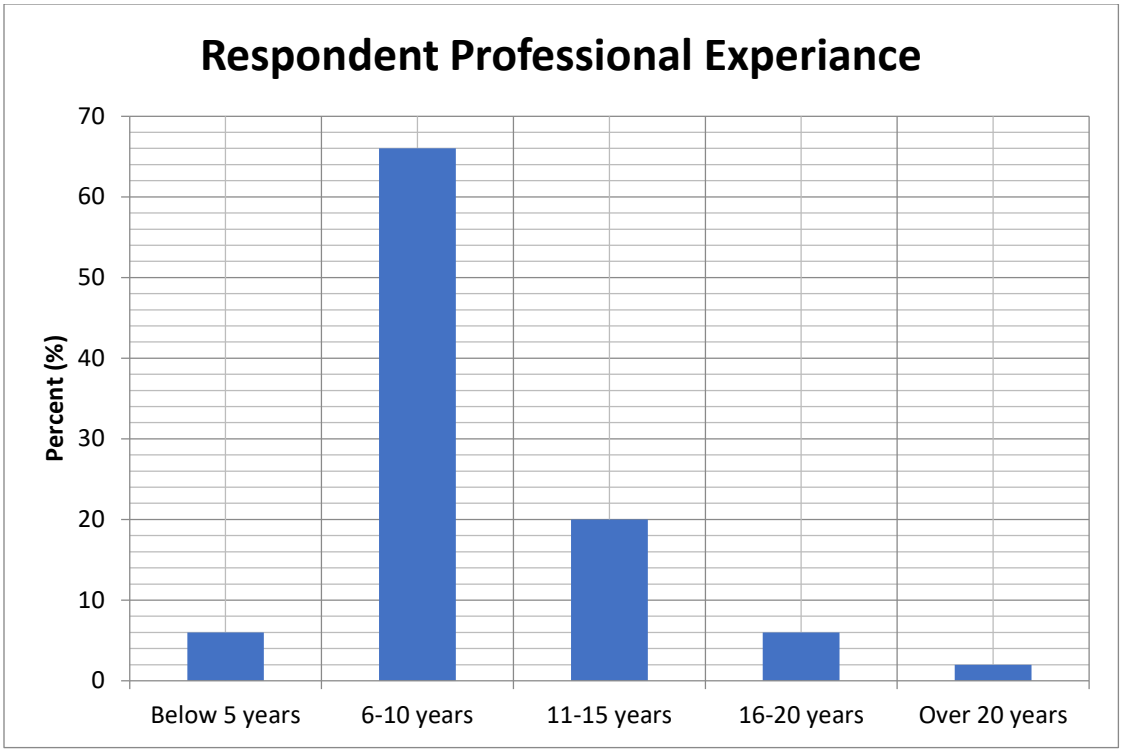

Figure 4.3- Respondent Professional Experience

4.3. Sustainability of Rural Road Construction

4.3.1. Environmental Sustainability of Rural Road Construction

Table 4.4 shows environmental sustainability of rural road construction. With an average mean of 4.01, respondents indicated that their disagreement to environmental sustainability of rural road construction in case of West Arsi zone of Oromia regional state. Among twelve rural road sustainability indicators investigated in the study, respondents rated their disagreement for use of prioritizing native soils/materials for construction (mean 4.64),disagreement to minimization of slope cutting and preservation of the vegetative cover (mean of 4.54), disagreement to use living plants to reduce slope instability and soil erosion (mean of 4.48), disagree to project Minimizing/ controlling noise, vibration, dust, and light trespassing during construction of rural road (mean of 4.22), and disagree with preserving water quality, capacity, and regime (e.g., keeping buffer between water body and road edge); (Proper water management) with (mean of 4.20) as being disagree. Respondents indicated that all environmental sustainability indicators are strongly

disagree and disagree to the respondents of the study in case of West Arsi zone of Oromia regional state.

Table 4.4- Respondents Response on Environmental Sustainability of Rural Road Construction

No.		N	Sum	Mean	Std. Deviation	Variance
1	Prioritizing native soils/materials for construction	50	232	4.64	.663	.439
2	Minimization of slope cutting and preservation of the vegetative cover	50	227	4.54	.838	.702
3	Use living plants to reduce slope instability and soil erosion	50	224	4.48	.886	.785
4	The project Minimizing/ controlling noise, vibration, dust, and light trespassing	50	211	4.22	.764	.583
5	Preserving water quality, capacity, and regime (e.g., keeping buffer between water body and road edge); (Proper water management)	50	210	4.20	1.443	2.082
6	Avoiding productive land loss (e.g., best agricultural soils);	50	208	4.16	.817	.668
7	The project use Environment Friendly Construction methods	50	204	4.08	1.589	2.524
8	Balancing earthwork quantities (cut and fill) during construction; (Mass balancing)	50	202	4.04	1.049	1.100
9	The project Reducing noise level to improve sleep quality and daytime sleepiness for children	50	197	3.94	.978	.956
10	Protecting endangered species and biodiversity; Protecting soil characteristics (e.g., mechanic, permeability, texture); Protecting green areas (e.g., avoiding deforestation and tree removal);	50	194	3.88	.872	.761
11	The project Reducing traffic emissions /improving local (and regional) air quality	50	184	3.68	1.039	1.079
12	The project Reducing materials wastage in construction	50	174	3.48	.580	.336
13	The project Protecting valuable habitats and natural (ecological) areas (e.g., wetlands, peat bogs, forest, semi-natural areas);	50	170	3.40	1.309	1.714
14	The project Providing on-site recycling and waste collection;	50	168	3.36	1.352	1.827
	Mean			4.01		
	Valid N (listwise)	50				

4.3.2. Social Sustainability of Rural Road Construction

The ethics of sustainability imply finding a balance between equity among humans in the present and equity between present and future generations. The principle of intergenerational equity and intergenerational equity is regarded as two of the fundamental pillars of the sustainable development. The role of sustainable rural road construction is to provide and enhance the quality of human life but, at same time, to protect the natural environment. In line to this this research was tried to assess social sustainability of rural road construction in case of West Arsi Zone of Oromia regional state. Table 4.5 shows that respondent's disagreement on social sustainability of rural road construction. With an average mean of 4.23, respondents indicated their disagreement on social sustainability of rural road construction which means out of twelve social sustainability indicators of rural road construction six of them or 50% as being shows their disagreement on social sustainability of rural road construction in case of West Arsi Zone of Oromia regional state.

Among twelve social sustainability indicators of rural road construction respondents rated as their disagreement on community employ for the routine road maintenance works (mean 4.76), Enhancing fiscal impacts (e.g., public revenues) (mean 4.56), The project Enhancing rural growth and economic activities (e.g., business, jobs/employment, wages, property value) (4.54), The project Reducing travel costs to lower expenses for all households and reducing travel time (4.54), and The projects are affordable and built within the financial limitations of local communities (4.50) as the top five respondents disagreement on sustainability of rural road construction. Which indicated that rural roads constructed in West Arsi zone can't provide and enhance the quality of human life those who lives around road construction areas.

Table 4.5- Respondents Response on Social Sustainability of Rural Road Construction

	N	Sum	Mean	Std. Deviation	Variance
The community employ for the routine road maintenance works	50	238	4.76	.716	.513
Enhancing fiscal impacts (e.g., public revenues)	50	228	4.56	.837	.700
The project Enhancing rural growth and economic activities (e.g., business, jobs/employment, wages, property value)	50	227	4.54	.579	.335
The project Reducing travel costs to lower expenses for all households and reducing travel time	50	227	4.54	.838	.702
The projects are affordable and built within the financial limitations of local communities	50	225	4.50	.909	.827
Selecting cost-effective design; Reducing space use for alignments	50	225	4.50	.931	.867
Improving energy efficiency in construction and operation	50	220	4.40	1.030	1.061
The project encourages the optimum uses of the local resources in the form of the local labor, local materials and local finance.	50	216	4.32	.794	.630
Reducing water uses in construction; Re-using stormwater for other purposes (e.g. Irrigation)	50	190	3.80	.904	.816
The project Reducing uses of non-renewable raw materials (e.g., fossil fuels)	50	190	3.80	.904	.816
The project Utilizing indigenous renewable energy (e.g., hydroelectricity)	50	189	3.78	.910	.828
The project control Foreign Exchange	50	164	3.28	1.341	1.798
Mean			4.23		
Valid N (listwise)	50				

4.3.3. Economical Sustainability of Rural Road Construction

Table 4.6 shows economical sustainability of rural road construction. With an average mean of 3.9, respondents indicated that their disagreement to economical sustainability of rural road construction in case of West Arsi zone of Oromia regional state. Among twelve rural road sustainability indicators investigated in the study, respondents rated their disagreement for use of Availability of institutional framework for effective implementation (mean 4.34), disagreement to Green rating system and its criteria (mean of 4.34), disagreement to Construction costs (mean of 4.00), disagree to Financial approval of sustainable rural road project (mean of 3.94), and disagree with Availability of financial and market-based incentives for adopters of sustainability (mean of 3.88) as being disagree and also disagreed to Availability of independent expertise to develop and design sustainable rural road with mean of 3.88 as well. So, respondents indicated that all economical sustainability indicators are strongly disagree and disagree to the respondents of the study in case of West Arsi zone of Oromia regional state.

Table 4.6- Respondents Response on Economic Sustainability of Rural Road Construction

No.		N	Sum	Mean	Std. Deviation	Variance
1	Availability of institutional framework for effective implementation	50	217	4.34	.479	.229
2	Green rating system and its criteria	50	217	4.34	.479	.229
3	Construction costs	50	200	4.00	.000	.000
4	Financial approval of sustainable rural road project	50	197	3.94	.867	.751
5	Availability of financial and market-based incentives for adopters of sustainability	50	194	3.88	.895	.802
6	Availability of independent expertise to develop and design sustainable rural road	50	194	3.88	.824	.679
7	Stakeholders' level of participation in sustainable rural road construction	50	194	3.88	.824	.679
8	Reliability of sustainable resources	50	194	3.88	1.043	1.087
9	Basic knowledge of sustainable rural road construction	50	193	3.86	.495	.245
10	Government policies and regulations (e.g., tax and incentives of sustainable construction)	50	180	3.60	.606	.367
11	Suitability of intended project area to maximize usage of sustainable rural road construction	50	180	3.60	.606	.367
12	Accessibility to resources, especially sustainable materials	50	180	3.60	.495	.245
	Mean			3.9		
	Valid N (listwise)	50				

4.4. Ranks of Rural Roads Sustainability Pillars

Sustainability generally denotes a balance of economic, social, and environmental goals with a long-term (intergenerational) concern. In transportation projects, SA is applied to evaluate whether a project "contributes to favor economic development and fulfill the transportation needs of the society in a manner consistent with ecological and human values". SA is an advanced methodology to ensure that decision-making is comprehensive and inclusive, meaning that it covers all three dimensions/pillars of sustainable development (i.e., environmental, social, and economic dimensions), including the indirect effects. Political ambition can play a huge part in the planning of road projects. Such projects have vital roles in enhancing regional growth and economic competitiveness, especially in developing countries. However, environmental aspects are relatively neglected and frequently only incorporated later on. Traditional impact assessment tools are often solely concerned with the environmental dimension, while the social and economic dimensions are less often considered for strategic environmental assessment of transportation projects. Figure 4.4 shows ranks of rural roads sustainability pillars.

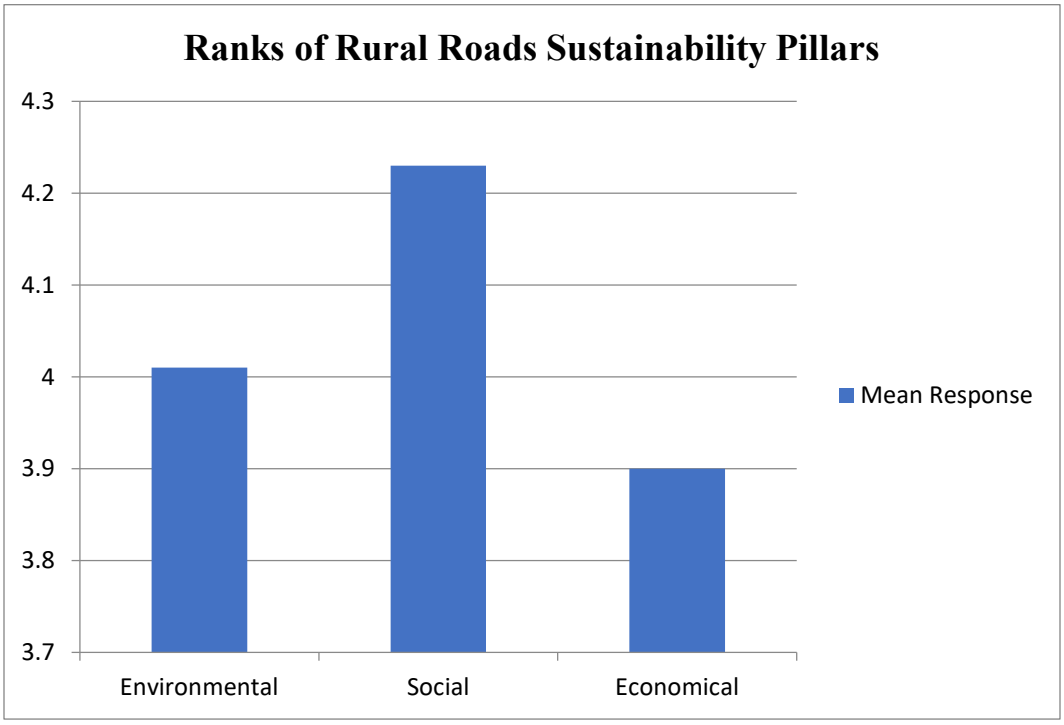

Figure 4.4- Ranks of rural roads sustainability pillars

Figure 4.4 shows that Social Sustainability of Rural Road Construction pillar has the highest respondents mean response, while Economical Sustainability of Rural Road Construction pillar has the lowest mean response. This indicate that, social sustainability has more impact on the sustainability of rural road construction than the other two pillars of rural road sustainability and economical sustainability has less impact on the sustainability of rural road construction.

4.5. Factors Influencing the Implementation of Sustainable Rural Road Construction

Table 4.7 ranks the factors influencing the implementation of sustainable rural road construction in case of Wast Arsi zone of Oromia regional state. With average mean of 3.9, the respondents indicated that all factors, significantly influence the adoption of sustainable rural road construction in the construction industry.

Respondents rated availability of institutional framework for effective implementation (mean 4.34), green rating system and its criteria (mean 4.34), construction costs (mean 4.00), financial approval of sustainable rural road project (mean 3.94) and Availability of financial and market-based incentives for adopters of sustainability (mean 3.88) as the top five factors that significantly influence the adoption of rural road construction.

Table 4.7- Factors Influencing the Implementation of Sustainable Rural Road Construction

No.		N	Mean	Std. Deviation	Variance
1	Construction costs	50	4.34	.479	.229
2	Government policies and regulations (e.g., tax and incentives of sustainable construction)	50	4.34	.479	.229
3	Basic knowledge of sustainable rural road construction	50	4.00	.000	.000
4	Financial approval of sustainable rural road project	50	3.94	.867	.751
5	Availability of financial and market-based incentives for adopters of sustainability	50	3.88	.895	.802
6	Availability of independent expertise to develop and design sustainable rural road	50	3.88	.824	.679
7	Stakeholders' level of participation in sustainable rural road construction	50	3.88	.824	.679
8	Reliability of sustainable resources	50	3.88	1.043	1.087
9	Availability of institutional framework for effective implementation	50	3.86	.495	.245
10	Green rating system and its criteria	50	3.60	.606	.367
11	Suitability of intended project area to maximize usage of sustainable rural road construction	50	3.60	.606	.367
12	Accessibility to resources, especially sustainable materials	50	3.60	.495	.245
	Mean		3.9		
	Valid N (listwise)	50			

4.6. Benefits of Implementing Sustainable Rural Road Construction

Table 4.8 shows environmental, economic and social benefits of sustainable road construction. With an average mean of 4.13, respondents indicated that all environmental benefits are important for sustainable rural road construction in the construction industry. Among ten environmental benefits investigated in the study, respondents rated Reduce wastage of water (M 4.60), Waste reduction (4.60), and Minimize noise pollution (mean of 4.34) and Climate regulation (4.12) as being very important.

With an average of mean of 3.87 respondents indicated that all economic benefits are important for sustainable rural road construction in the construction industry. Respondents rated more revenue opportunities (Mean), Increase of poverty value (mean 4.06), Optimizes the life cycle of the road (mean 3.93), and allow for competitive tendering (mean 3.66) as the top four economic benefit of sustainable rural road construction.

With an average of 3.96, respondents indicated that all social benefits are important for sustainable rural road construction in the construction industry. Five social benefits were identified for the study and three of them were rated as being important. The last social benefits were rated as being averagely important.

For the combined environmental, economic, and social) benefits of sustainable rural road construction, two of the 20 combined benefits investigated in the study were found to be very important, and the remainder were found to be important. The top one benefit of sustainable rural road construction as rated by the respondents are social benefit: Improve quality of life and the remain top four rated by the respondents were environmental benefits: Reduce wastage of water, Waste reduction, as well as Climate regulation.

Table 4.8- Benefits of Sustainable Road Construction

No.	Benefits		N	Sum	Mean	Std. Deviation	Variance
1	Improve quality of life	Social	50	230	4.60	.808	.653
2	Reduce wastage of water	Environmental	50	230	4.60	.808	.653
3	Waste reduction	Environmental	50	220	4.40	.808	.653
4	Minimize noise pollution	Environmental	50	217	4.34	.798	.637
5	Climate regulation	Environmental	50	206	4.12	.718	.516
6	Improves worker productivity	Social	50	206	4.12	.718	.516
7	Maintenance savings	Environmental	50	203	4.06	.240	.058
8	Temperature control	Environmental	50	203	4.06	.240	.058
9	More revenue opportunity	Economic	50	203	4.06	.682	.466
10	Protect biodiversity and ecosystems	Environmental	50	203	4.06	.682	.466
11	Increase of poverty value	Economic	50	203	4.06	.682	.466
12	Conserve natural resources		50	196	3.92	1.066	1.136
13	Optimizes the life cycle of the road	Economic	50	196	3.92	1.066	1.136
14	Improve air and water quality	Environmental	50	193	3.86	.808	.653
15	Increase users overall moral	Social	50	193	3.86	1.030	1.062
16	Create pleasing environment		50	193	3.86	.495	.245
17	Allow for competitive tendering	Economic	50	183	3.66	.872	.760
18	Reduce operating cost	Economic	50	183	3.66	.872	.760
19	Improve users' health and comfort	Social	50	180	3.60	.606	.367
20	Minimize strain on local infrastructure	Social	50	180	3.60	.606	.367
	Mean				4.02		
	Valid N (listwise)		50				

4.7. Challenges for Implementation of Sustainable Rural Road Construction

Sustainable construction also has inherent challenges that hamper its effective adoption. (Kehagia, 2009) identified financial constraints, inadequate proactive plans, inefficient technology, an insufficient commitment of upper-level management, insufficient environmental competencies, lack of awareness among stakeholders, lack of sustainable waste management, lack of workers' training in sustainable operations, management's unwillingness, political impacts, and preferences of suppliers/institutional buyers as the barriers to the effective adoption of sustainable construction in the United States. In Nelson Mandela Bay, it was noted that perceived increased upfront costs, high material costs, minimum standard requirements, and lack of specialist knowledge are the main barriers to the full uptake of sustainable construction (Kehagia, 2009)

The Commission for Environmental Cooperation (Basiago, 1451a) advanced the following barriers: separate capital and operating budgets, split incentives, higher perceived/actual first costs, risks and uncertainties, lack of experienced workforce, lack of coordination and consistency in government policies, lack of investment in research, and issues specific to the region. Simple and Smallwood (2015: 96) identified the following barriers: capacity barriers, cultural and social resistances, lack of incentives to promote sustainable building, inadequate cost data for sustainable buildings, inadequate information regarding the financial and economic benefits and opportunities of sustainable buildings, limited range of sustainable materials, and delays in obtaining certifications and permits for sustainable buildings.

The following table, table 4.9 indicates the challenges with the adoption of sustainable rural road construction. With an average mean of 3.678, the respondents indicated that all challenges significantly hinder the use of sustainable rural road construction systems.

One out of 20 challenges investigated in the study was rated as being very significant and remaining were rated as significant. Hence the top five challenges that hinder the adoption of sustainable rural road construction are lack of sustainable construction process (M 3.92), lack of finance to attain an accredited sustainable contractor (M3.90), lack of sustainable construction technology (M3.9), resource scarcity (M3.82) as well as Lack of compulsory green system accreditation requirements (M 3.766).

Table 4.9- Challenges with the Implementation of Sustainable Rural Road Construction

Challenges	N	Sum	Mean	Std. Deviation	Variance
Lack of sustainable construction processes	50	196	3.92	.922	.851
Lack of finances to attain an accredited sustainable contractor	50	195	3.90	.647	.418
Lack of sustainable construction technology	50	195	3.90	.647	.418
Resource scarcity	50	191	3.82	.850	.722
Lack of compulsory green system accreditation requirements	50	188	3.76	.870	.758
Lack of finances to attain sustainable systems	50	188	3.76	.870	.758
Lack of monitoring operations	50	188	3.76	.870	.758
Lack of government incentives in public sector	50	188	3.76	.870	.758
Lack of finances to attain sustainable materials	50	188	3.76	.870	.758
Lack of government incentives in the private sector	50	185	3.70	.953	.908
Lack of social viability	50	185	3.70	.735	.541
Lack of environmental viability	50	183	3.66	.688	.474
Lack of set targets of implemented sustainable construction systems	50	183	3.66	.688	.474
Lack of stakeholder participation	50	183	3.66	.688	.474
Lack of innovative sustainable materials	50	181	3.62	.901	.812
Lack of innovation	50	178	3.56	.907	.823
Monetary and budget boundaries	50	178	3.56	.907	.823
lack of financial viability	50	173	3.46	.706	.498
Lack of knowledge on sustainable rural road construction systems	50	171	3.42	.883	.779
A weak economy	50	161	3.22	.545	.298
Average mean			3.678		
Valid N (listwise)	50				

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSIONS

Sustainable way is the best way of doing anything. Sustainable rural road construction is a sustainable way of constructing the rural road in Ethiopia. The sustainable rural road approach considered environments, social, and economic issues of the country. Sustainable rural road approach adopts the mass balancing as the environment friendly approach and more importantly it utilizes the various soil bioengineering techniques to ensure stability of slope and control of the erosion. Sustainable rural road approach promotes the optimum utilization of local construction materials, equipment's and local people participation in each stage of the project.

The Sustainable rural road ensures the decentralized approach through the participation of the local stakeholders and communities throughout the project life cycle from planning to the implementation. The Sustainable rural road approach strongly addresses the social inequalities and disparity within the society. It adopts the poverty alleviation measures through the employment generation during construction to the income generating activities through the self-help promotion or local level capacity building. It encourages the local to take the ownership of the road for the sustainable maintenance of the rural roads.

The study investigated sustainability of rural road construction in case of West Arsi Zone of Oromia regional state. As the finding indicated that the construction process was not adopt sustainable rural road construction approach in terms of environmental, social and economic indicators. And the study investigated the factors and effects of adopting sustainable rural road construction. Based on the findings the study conclude that the cost of sustainable construction is the topmost factor considered for its adoption. In addition, the availability of human resources and sustainable materials hampers the adoption of sustainable rural road construction. Lack of knowledge of sustainable rural road construction is significant to the adoption of sustainable construction. Other factors of sustainable rural road construction are government policies, weather condition, and market incentives. Furthermore, the study concluded that there are natural factors of sustainable construction that can hamper sustainable construction and require further efforts for successful adoption.

Conservation of natural resources, reduction of water wastages, and waste reduction are the most significant benefits of adopting sustainable rural road construction. The environmental benefits of sustainable construction are at the top (above social and economic benefits) of all the benefits of sustainable rural road construction. The top social benefits of sustainable construction are improvement of the quality of life, minimization of strain on local infrastructure, and improvement of occupants' health and comfort. The top economic benefits of sustainable construction are revenue opportunities, utilities savings, and maintenance savings. Hence, the study concluded that environmental preservation is the thrust of sustainability above the social and economic values. Lastly, the study concluded that lack of knowledge on sustainable system, weak economy or poverty, lack of government incentives and regulations, lack of money to acquire sustainable materials, and lack of monitoring operation and innovation are the top challenges with the adoption of sustainable rural road construction in case of West Arsi Zone of Oromia regional state.

5.2 RECOMMENDATIONS

Based on the findings of the study, the following recommendations are drawn for construction stakeholders.

- construction stakeholders need to develop a mechanism for overcoming the natural factors that hamper the adoption of sustainable construction.
- Government also needs to create an enabling environment for the practice of sustainable construction through favorable policies and regulations.
- These regulations would go a long way in mitigating challenges such as market and financial incentives, availability of sustainable materials, cost of sustainable construction, and certification for green buildings.
- Awareness through educational institutions, professional bodies, and conferences needs to be done so that the adoption of sustainable construction can be encouraged and improved.
- financial support and funding for sustainable rural road projects should be considered critically in adopting sustainable rural road construction concepts in road construction. However, this criterion can be achieved if governments support private developers by providing tax incentives to private developers utilizing sustainable construction principles to deliver road infrastructure projects. This can be in the form of directives or strategies in a policy document. The cost of using these sustainable construction concepts could be shared among the private developers and the government.
- raising awareness of sustainability issues and promoting sustainable policies in the road sector needs careful consideration in adopting sustainable construction concepts in road construction projects.
- Governments and developers need to implement policies and measures to raise awareness of the huge benefits of sustainable construction concepts in road construction.

6. REFERANCES

Asomani-Boateng, R., Fricano, R. J., & Adarkwa, F. (2015). Assessing the socio-economic impacts of rural road improvements in Ghana: A case study of Transport Sector Program Support (II). Case Studies on Transport Policy, 3(4), 355–366. https://doi.org/10.1016/j.cstp.2015.04.006

Basiago, A. D. (1451a). Economic, social, and environmental sustainability in development theory and urban planning practice. In The Environmentalist (Vol. 19). Kluwer Academic Publishers.

Basiago, A. D. (1451b). Economic, social, and environmental sustainability in development theory and urban planning practice. In The Environmentalist (Vol. 19). Kluwer Academic Publishers.

Bekele Kilisa, A. (2021). ASSESSMENT OF THE IMPACT OF RURAL ROAD TRANSPORT ON SOCIO-ECONOMIC DEVELOPMENT. (A CASE STUDY: TULLA-KENERA-YAYE ROAD SECTION) MSc THESIS.

Belachew, A. S., Mengesha, W. J., & Mohammed, M. (2017). Causes of Cost Overrun in Federal Road Projects of Ethiopia in Case of Southern District. 5(1), 27–40. https://doi.org/10.11648/j.ajce.20170501.15

Chaka Advisor, -Gizaw, & Atsede Tesfaye, -Dr. (2021). Assessment of Green Building Construction Project Management Practice in Addis Ababa A Research Project submitted in Partial Fulfillment of the Requirements for the Award of Master of Arts Degree in Project Management.

Chamorro Giné, M. A. (2012). Development of a Sustainable Management System for Rural Road Networks in Developing Countries. 202.

Danso, H., Annor, J., & Resources, N. (2013). ASSESSMENT OF THE PERFORMANCE OF LOCAL AND FOREIGN ROAD CONSTRUCTION FIRMS IN. January 2014. https://doi.org/10.1080/15623599.2013.10878229

Das Mulmi, A. (2009). Green Road Approach in Rural Road Construction for the Sustainable Development of Nepal.

Ekung, S. B. (2017). Small and Medium Scale Contractors' Perception of the Factors Affecting Production Cost of Building Projects in Nigeria Evaluation of the Level of Adoption of Sustainability Practices among Construction Firms in Niger-Delta, Nigeria View project. March. https://www.researchgate.net/publication/314395797

Engineering, S., Kong, H., Road, P., & Received, H. K. (n.d.). projects.

Garg, A., & Yadav, H. (n.d.). Framework for Durable and Economical Construction of Rural Roads in India. In International Journal of Constructive Research in Civil Engineering (IJCRCE) (Vol. 1, Issue 2). www.arcjournals.org

Gómez-Cabrera, A., Sanz-Benlloch, A., Montalban-Domingo, L., Ponz-Tienda, J. L., & Pellicer, E. (2020). Identification of factors affecting the performance of rural road projects in Colombia. Sustainability (Switzerland), 12(18). https://doi.org/10.3390/SU12187377

Gyadu-Asiedu, W., Ampadu-Asiamah, A., & Fokuo-Kusi, A. (2021). A framework for systemic sustainable construction industry development (SSCID). Discover Sustainability, 2(1). https://doi.org/10.1007/s43621-021-00033-y

Iimi, A., Lancelot, E., Manelici, I., & Ogita, S. (2015). Evaluating the Social and Economic Impacts of Rural Road Improvements in the State of Tocantins, Brazil (LCSSD) fund, Poverty and Social Impact Analysis (PSIA) grant.

Kehagia, F. (2009). The implementation of sustainability in highway projects. International Journal of Sustainable Development and Planning, 4(1), 61–69. https://doi.org/10.2495/SDP-V4-N1-61-69

Lombard, P., & Coetzer, L. (n.d.). THE ESTIMATION OF THE IMPACT OF RURAL ROAD INVESTMENTS ON SOCIO-ECONOMIC DEVELOPMENT.

Lombeso, A., & Berhanu, E. (2018). CHALLENGES IN URBAN INFRASTRUCTURE SERVICE PROVISION: THE CASE OF WATER, POWER AND ROAD SUB SECTOR IN HOSSANA TOWN, SNNPRS Public Administration and Development Management (PADM) in partial fulfillment of the requirement for the Degree of MA Addis Ababa.

Mary', S. T., & Seife, T. (2019). SCHOOL OF GRADUATE STUDIES Challenges in Applying Integrated Project Management System on Urban Infrastructure Projects: The Case of Addis Ababa Road Projects, Major Utilities Projects and Infrastructure Regulatory.

Montgomery, R., Schirmer, H., & Hirsch, A. (2015). IMPROVING ENVIRONMENTAL SUSTAINABILITY IN ROAD PROJECTS.

Mustafa, N. A., Munikanan, V., Zakaria, R., Aminudin, E., Langie, S., Adzar, J. A., Abd Rashid, M. H. S., Shamsudin, S. M., Sooria, S. Z., & Hassan, M. M. (2022a). An Assessment of Green Rural Road Criteria and Elements for My Green Rural Road Index: A Case Study in Pengerang, Johor. IOP Conference Series: Earth and Environmental Science, 971(1). https://doi.org/10.1088/1755-1315/971/1/012001

Mustafa, N. A., Munikanan, V., Zakaria, R., Aminudin, E., Langie, S., Adzar, J. A., Abd Rashid, M. H. S., Shamsudin, S. M., Sooria, S. Z., & Hassan, M. M. (2022b). An Assessment of Green Rural Road Criteria and Elements for My Green Rural Road Index: A Case Study in Pengerang, Johor. IOP Conference Series: Earth and Environmental Science, 971(1). https://doi.org/10.1088/1755-1315/971/1/012001

Of, A., Qualification, C., Road, F., & Tender, P. (2015). ADDIS ABABA INSTITUTE OF TECHNOLOGY SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING Approved By Board of Examiners.

Program, A. I. D., Anderson, G. W., Vandervoort, C. G., Suggs, C. M., & Clapp-Wincek, C. (1982). RURAL ROADS EVALUATION SUMMARY REPORT With the assistance of.

Sarkar, A. K. (2011). Transport and Communications Bulletin for Asia and the Pacific DEVELOPMENT OF A SUSTAINABLE RURAL ROADS MAINTENANCE SYSTEM IN INDIA: KEY ISSUES.

Singru, N. (2009a). Performance Evaluation Report Independent Evaluation Department Lao People's Democratic Republic: Rural Access Roads Project.

Singru, N. (2009b). Performance Evaluation Report Independent Evaluation Department Lao People's Democratic Republic: Rural Access Roads Project.

Suprayoga, G. B., Bakker, M., Witte, P., & Spit, T. (2020). A systematic review of indicators to assess the sustainability of road infrastructure projects. European Transport Research Review, 12(1). https://doi.org/10.1186/s12544-020-0400-6

Tunji-olayeni, P., Mosaku, T. O., Fagbenle, O. I., Omuh, I. O., & Joshua, O. (2016). Evaluating Construction Project Performance : A Case of Construction SMEs in Lagos , Nigeria. 2016. https://doi.org/10.5171/2016.482398

Yang, Y., Ng, S. T., Xu, F. J., & Skitmore, M. (2018). Towards sustainable and resilient high density cities through better integration of infrastructure networks. Sustainable Cities and Society, 42, 407–422. https://doi.org/10.1016/j.scs.2018.07.013

7. APPENDIX A

Questionaries' survey

Dear sir/madam, this questionnaire is prepared by master's program student in Adama Science and Technology University, department of civil engineering construction engineering and management stream. this study entitled "**assessment of sustainable rural road construction approach: the case of West Arsi zone, Oromia, Ethiopia**" is designed to assess the sustainability of rural road construction projects in case of west arsi zone to identify factors affecting for adoption of sustainable rural road construction concept in case of West Arsi zone, Oromia, to assess the impact of rural road construction on socio-economic development in case of West Arsi zone and to fill the gap on a shortage of studies on the sustainability of rural road construction in our country.

It aims to collect information related to sustainable rural road construction projects. the information given is for academic purpose only and will be treated as very confidential. any form of support is greatly appreciated.

thank you in advance for taking your precious time to fill this questionnaire. please try to answer all the questions openly, as your answers will have an influence on the outcome of the research. your 15 minutes or less will greatly contribute to growth of sustainable rural road construction in ethiopia.

if you have any questions or comments, please don't hesitate to contact me. you can each me by; cell phone: +251917514374 e-mail:

Section I. General Profile of the Respondent

1. Name of your company: _____
2. Project name: _____
3. Location: _____
4. Respondent
   Profession/job title: _____
5. Profession

A. Architect B. construction/project manager C. Quantity surveyor

6. Academic qualification

A. Diploma
B. Bachelor's degree
C. Master's degree
D. Doctorate degree

7. Professional
   experience

A. Below 5 years
B. 6-10
C. 11-15
D. 16-20
E. Over 20

8. Professional experience

A.Below 5 years

B. 6-10

C.11-15

D.16-20

E.Over 20

9. On a scale of one to five how familiar are you with the concept sustainable rural road construction? Where 1= Not Familiar to 5= Completely Familiar

   A. 1 B. 2 C. 3 D. 4 E. 5

10. Has your company ever been involved on a sustainable rural road project?

    A. Yes
    B. No
    C. I'm not sure

Section II: Assessing the Sustainability Practices of Rural Road Projects in Case of West Arsi Zone, Oromia, Ethiopia

Below are listed indicators of sustainability on rural road projects to assesses the sustainability of rural road projects in case of west Arsi zone Oromia, Ethiopia. From your experience, please express your opinion to rate the following statements, on a scale of 1 to 5, according to the best of your knowledge. 1 represents 'I fully agree' 2 = Agree, 3= Neutral, 4= Disagree and 5 represents 'I fully disagree' (Please put a tick mark in the appropriate column according to their degree of rank) (Gyadu-Asiedu et al., 2021).

No.	Environment Sustainability	1	2	3	4	5
1	The project Reducing traffic emissions (nox, CO, PM > 10, CO2)/improving local (and regional) air quality;					
2	The project Reducing materials wasted in construction;					
3	The project Providing on-site recycling and waste collection; Protecting watercourses (e.g., lakes) in construction.					
4	Minimization of slope cutting and preservation of the vegetative cover					
5	The project Minimizing/ controlling noise, vibration, dust, and light trespassing;					
6	Balancing earthwork quantities (cut and fill) during construction; (Mass balancing)					
7	The project use Environment Friendly Construction methods					
8	Preserving water quality, capacity, and regime (e.g., keeping buffer between water body and road edge); (Proper water management)					
9	Use living plants to reduce slope instability and soil erosion					
10	The project Reducing noise level to improve sleep quality and daytime sleepiness for children					
11	The project Protecting valuable habitats and natural (ecological) areas (e.g., wetlands, peat bogs, forest, semi-natural areas);					

12	Protecting endangered species and biodiversity; Protecting soil characteristics (e.g., mechanic, permeability, texture); Protecting green areas (e.g., avoiding deforestation and tree removal);					
13	Prioritizing native soils/materials for construction;					
14	Avoiding productive land loss (e.g., best agricultural soils);					
2	Social Sustainability					
1	Poverty alleviation through income and employment generation					
2	Decentralization and participatory approach					
3	Local level capacity building					
4	Low caste and disadvantage group participate					
5	Project provides the equal opportunities for men and women					
6	Avoiding natural and human capital losses because of traffic emissions					
7	Protecting archaeological and historic resources;					
8	Reducing accident risks in rural areas;					
9	Mitigating emission effects on human health					
10	Protecting landscape and human-made heritage;					
	Sustainable Economy					
1	The project Enhancing rural growth and economic activities (e.g., business, jobs/employment, wages, property value);					
2	The project Reducing travel costs to lower expenses for all households and reducing travel time;					
3	*The* project encourages the optimum uses of the local resources in the form of the local labor, local materials and local finance. Utilizing locally obtained materials for construction					
4	Reducing water uses in construction; Re-using stormwater for other purposes (e.g. Irrigation)					
5	*The* project Utilizing indigenous renewable energy (e.g., hydroelectricity)					

6	*The* project Reducing uses of non-renewable raw materials (e.g., fossil fuels);					
7	Selecting cost-effective design; Reducing space use for alignments;					
8	Improving energy efficiency in construction and operation;					
9	*The* project control Foreign Exchange					
10	The projects are affordable and built within the financial limitations of local communities.					
11	The community employ for the routine road maintenance works					
12	Enhancing fiscal impacts (e.g., public revenues);					

Section III: Factors Influencing the Adoption of Sustainable Rural Road Construction in the Construction Industry In Case Of West Arsi Zone, Oromia, Ethiopia

1 = Not significant (≥1.00 and ≤1.49); 2 = Slightly significant (≥1.50 and ≤2.49); 3 = Averagely significant (≥2.50 and ≤3.49); 4 = Significant (≥3.50 and ≤4.49), and 5 = Very significant (≥4.50 and ≤5.00).

(Please put a tick mark in the appropriate column according to their degree of rank).

No.	**Factors hindering the use of sustainable rural road construction systems**	1	2	3	4	5
1	Construction costs					
2	Accessibility to resources, especially sustainable materials					
3	Basic knowledge of sustainable rural road construction					
4	In appropriate use of government policies and regulations (e.g., tax and incentives of sustainable construction)					
5	Suitability of intended project area to maximize usage of sustainable rural road construction					

6	Availability of financial and market-based incentives for adopters of sustainability					
7	Green rating system and its criteria					
8	Financial approval of sustainable rural road project					
9	Reliability of sustainable resources					
10	Stakeholders' level of participation in sustainable rural road construction					
11	Availability of independent expertise to develop and design sustainable rural road					
12	Availability of institutional framework for effective implementation					

Section IV: Benefits of Sustainable Rural Road Construction In Case Of West Arsi Zone, Oromia, Ethiopia

1 = Not important (≥1.00 and ≤1.49); 2 = Slightly important (≥1.50 and ≤2.49); 3 = Averagely important (≥2.50 and ≤3.49); 4 = Important (≥3.50 and ≤4.49), and 5 = Very important (≥4.50 and ≤5.00)

No.	**Benefits sustainable rural road construction**	1	2	3	4	5
1	Reduce operating cost					
2	Allow for competitive tendering					
3	Decrease level of poverty					
4	Optimizes the life cycle of the road					
5	Create pleasing environment					
6	Increase users overall moral					
7	Improves worker productivity					
8	Conserve natural resources					
9	Reduce wastage of water					
10	Waste reduction					
11	Improve air and water quality					

12	Protect biodiversity and ecosystems					
13	Climate regulation					
14	More revenue opportunity					
15	Minimize noise pollution					
16	Improve quality of life					
17	Temperature control					
18	Minimize strain on local infrastructure					
19	Maintenance savings					
20	Improve users' health and comfort					

Section V: Factors hindering the use of sustainable rural road construction systems in case of West Arsi zone, Oromia, Ethiopia

1 = Not significant (≥1.00 and ≤1.49); 2 = Slightly significant (≥1.50 and ≤2.49); 3 = Averagely significant (≥2.50 and ≤3.49); 4 = Significant (≥3.50 and ≤4.49), and 5 = Very significant (≥4.50 and ≤5.00).

No.	**Factors hindering the use of sustainable construction systems**	**1**	**2**	**3**	**4**	**5**
1	Lack of knowledge on sustainable rural road construction systems					
2	A weak economy					
3	Lack of government incentives in the private sector					
4	Lack of finances to attain sustainable materials					
5	Monetary and budget boundaries					
6	Lack of government incentives in public sector					
7	Lack of monitoring operations					
8	Lack of innovation					
9	Lack of finances to attain sustainable systems					
10	Lack of stakeholder participation					
11	Lack of compulsory green system accreditation requirements					
12	Lack of innovative sustainable materials					

13	lack of financial viability					
14	Lack of sustainable construction technology					
15	Lack of set targets of implemented sustainable construction systems					
16	Lack of sustainable construction processes					
17	Lack of social viability					
19	Resource scarcity					
20	Lack of environmental viability					
21	Lack of finances to attain an accredited sustainable contractor					

Appendix B

Goggle form Questionaries' survey

Questionnaire survey

Dear sir/madam, this questionnaire is prepared by master's program student in Adama Science and Technology university, department of civil engineering construction engineering and management stream. this study entitled "**assessment on sustainable rural road construction approach: the case of West Arsi zone, Oromia, Ethiopia**" is designed to assess the sustainability of rural road construction projects in case of West Arsi zone, Oromiya regional state, Ethiopia to identify factors affecting for adoption of sustainable rural road construction concept in case of West Arsi zone, Oromia, to assess the impact of rural road construction on socio-economic development in case of West Arsi zone and to fill the gap on a shortage of studies on the sustainability of rural road construction in our country.

It aims to collect information related to sustainable rural road construction projects. the information given is for academic purpose only and will be treated as very confidential.

any form of support is greatly appreciated.

thank you in advance for taking your precious time to fill this questionnaire. please try to answer all the questions openly, as your answers will have an influence on the outcome of the research. your 15 minutes or less will greatly contribute to growth of sustainable rural road construction in ethiopia.

if you have any questions or comments, please don't hesitate to contact me. you can each me by;

cell phone: +251917514374

Sign in to Google to save your progress. Learn More

Next Clear form

Questionnaire survey

Sign in to Google to save your progress. Learn More

General profile of the respondent

Name of your company

Your answer

Location

Your answer

Respondent profession/job title

Your answer

1. Professional Experience

- ◯ Below 5 years
- ◯ 6-10 years
- ◯ 11-15 years
- ◯ 16-20 years
- ◯ Above 20 years

Un a scale of one to five how familiar are you with the concept sustainable rural road construction? Where 1= Not Familiar to 5= Completely Familiar

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

Has your company ever been involved on a sustainable rural road project?

- ◯ Yes
- ◯ No
- ◯ I am not s ure

Previous Next Clear form

Questionnaire survey

Sign in to Google to save your progress. Learn More

Assessment on sustainability of Rural Road projects in case of West Arsi zone, Oromia, Ethiopia

Below
are listed indicators of sustainability on
rural road projects to assesses the sustainability of rural road projects in case of west Arsi zone Oromia, Ethiopia. From your experience, please express your opinion to rate the following statements, on a scale of 1 to 5, according to the best of your knowledge. 1 represents 'I fully agree' 2 = Agree, 3= Neutral, 4= Disagree and 5 represents 'I fully disagree' (Please put a tick mark in the appropriate column according to their degree of rank).

Assessment on Environment Sustainability of Rural Road construction

	Fully agree	Agree	Neutral	Disagree	I fully disagree
The project Reducing traffic emissions (nox, CO, PM > 10, CO2)/improving local (and regional) air quality	☐	☐	☐	☐	☐
The project Reducing materials wasted in construction	☐	☐	☐	☐	☐

The project Providing on-site recycling and waste collection;	☐	☐	☐	☐	☐
Minimization of slope cutting and preservation of the vegetative cover	☐	☐	☐	☐	☐
The project Minimizing/ controlling noise, vibration, dust, and light trespassing	☐	☐	☐	☐	☐
Balancing earthwork quantities (cut and fill) during construction; (Mass balancing)	☐	☐	☐	☐	☐
The project use Environment Friendly Construction methods	☐	☐	☐	☐	☐
Preserving water quality, capacity, and regime (e.g., keeping buffer between water body and road edge); (Proper water management)	☐	☐	☐	☐	☐

Prioritizing native soils/materials for construction;	☐	☐	☐	☐	☐
Avoiding productive land loss (e.g., best agricultural soils)	☐	☐	☐	☐	☐

Assessment on Economic Sustainability of Rural Road construction

	I fully agree	Agree	Neutral	Disagree	I fully disagree
The project Utilizing indigenous renewable energy (e.g., hydroelectricity)	☐	☐	☐	☐	☐
Improving energy efficiency in construction and operation	☐	☐	☐	☐	☐
The projects are affordable and built within the financial limitations of local communities	☐	☐	☐	☐	☐

The project Enhancing rural growth and economic activities (e.g., business, jobs/employment, wages, property value)	☐	☐	☐	☐	☐
The project Reducing travel costs to lower expenses for all households and reducing travel time	☐	☐	☐	☐	☐
The community employ for the routine road maintenance works	☐	☐	☐	☐	☐

Assessment on Social Sustainability of Rural Road construction

	I fully agree	Agree	Neutral	Disagree	I fully disagree
Poverty alleviation through income and employment generation	☐	☐	☐	☐	☐
Decentralization and participatory approach	☐	☐	☐	☐	☐

Local level capacity building	☐	☐	☐	☐	☐
Low caste and disadvantage group participate	☐	☐	☐	☐	☐
Project provides the equal opportunities for men and women	☐	☐	☐	☐	☐
Avoiding natural and human capital losses because of traffic emissions	☐	☐	☐	☐	☐
Protecting archaeological and historic resources;	☐	☐	☐	☐	☐
Reducing accident risks in rural areas;	☐	☐	☐	☐	☐
Mitigating emission effects on human health	☐	☐	☐	☐	☐
Protecting landscape and human-made heritage;	☐	☐	☐	☐	☐

Previous Next Clear form

Questionnaire survey

Sign in to Google to save your progress. Learn More

Factors affecting for adoption of sustainable rural road construction concept in case of West Arsi zone, Oromia, Ethiopia

Below
are list of factors affecting for adoption of sustainable rural road construction concept from your experience, please express your opinion on the importance of the following factors influencing the adoption of sustainable rural road construction concept in West Arsi zone, Oromia. (Please put a tick mark in the appropriate column according to their degree of rank using a 5-point Likert scale (1=not significant at all; 5=most significant).

Factors influencing the adoption of sustainable Rural Road construction.

	Not significant	Slightly significant	Averagely significant	Significant	Very significant
Construction costs	☐	☐	☐	☐	☐
Accessibility to resources, especially sustainable materials	☐	☐	☐	☐	☐
Basic knowledge of sustainable rural road construction	☐	☐	☐	☐	☐

market-based incentives for adopters of sustainability	☐	☐	☐	☐	☐
Green rating system and its criteria	☐	☐	☐	☐	☐
Financial approval of sustainable rural road project	☐	☐	☐	☐	☐
Reliability of sustainable resources	☐	☐	☐	☐	☐
Stakeholders' level of participation in sustainable rural road construction	☐	☐	☐	☐	☐
Availability of independent expertise to develop and design sustainable rural road	☐	☐	☐	☐	☐
Availability of institutional framework for effective implementation	☐	☐	☐	☐	☐

Previous Next Clear form

Questionnaire survey

Sign in to Google to save your progress. Learn More

Benefits of sustainable rural road construction in case of West Arsi zone, Oromia, Ethiopia

1
= Not important (≥1.00 and ≤1.49); 2 = Slightly important (≥1.50 and ≤2.49); 3
= Averagely important (≥2.50 and ≤3.49); 4 = Important (≥3.50 and ≤4.49), and 5
= Very important (≥4.50 and ≤5.00)

Benefits of sustainable rural road construction.

	Not important	Slightly important	Averagely important	Important
Reduce operating cost	☐	☐	☐	☐
Allow for competitive tendering	☐	☐	☐	☐
Increase of poverty value	☐	☐	☐	☐
Create pleasing environment	☐	☐	☐	☐
Increase users overall moral 5	☐	☐	☐	☐
Improves worker productivity	☐	☐	☐	☐

Reduce wastage of water	☐	☐	☐	☐
Waste reduction	☐	☐	☐	☐
Improve air and water quality	☐	☐	☐	☐
Protect biodiversity and ecosystems	☐	☐	☐	☐
Climate regulation	☐	☐	☐	☐
More revenue opportunity	☐	☐	☐	☐
Minimize noise pollution	☐	☐	☐	☐
Improve quality of life	☐	☐	☐	☐
Temperature control	☐	☐	☐	☐
Minimize strain on local infrastructure	☐	☐	☐	☐
Maintenance savings	☐	☐	☐	☐
Improve users' health and comfort	☐	☐	☐	☐

Previous Next Clear form

Factors hindering the use of sustainable rural road construction systems in case of West Arsi zone, Oromia, Ethiopia

1 = Not significant (≥1.00 and ≤1.49); 2 = Slightly significant (≥1.50 and ≤2.49); 3 = Averagely significant (≥2.50 and ≤3.49); 4 = Significant (≥3.50 and ≤4.49), and 5 = Very significant (≥4.50 and ≤5.00).

Factors hindering the use of sustainable rural road construction systems.

	Not significant	Slightly significant	Averagely significant	Significant	Very significant
Lack of knowledge on sustainable rural road construction systems	☐	☐	☐	☐	☐
A weak economy	☐	☐	☐	☐	☐
Lack of government incentives in the private sector	☐	☐	☐	☐	☐
Lack of finances to attain sustainable materials	☐	☐	☐	☐	☐
Monetary and budget boundaries	☐	☐	☐	☐	☐

lack of financial viability	☐	☐	☐	☐	☐
Lack of sustainable construction technology	☐	☐	☐	☐	☐
Lack of set targets of implemented sustainable construction systems	☐	☐	☐	☐	☐
Lack of sustainable construction processes	☐	☐	☐	☐	☐
Lack of social viability	☐	☐	☐	☐	☐
Resource scarcity	☐	☐	☐	☐	☐
Lack of environmental viability	☐	☐	☐	☐	☐
Lack of finances to attain an accredited sustainable contractor	☐	☐	☐	☐	☐

Previous Send Clear form