

ANNEX-1

FIELD INVENTORY PHOTOS

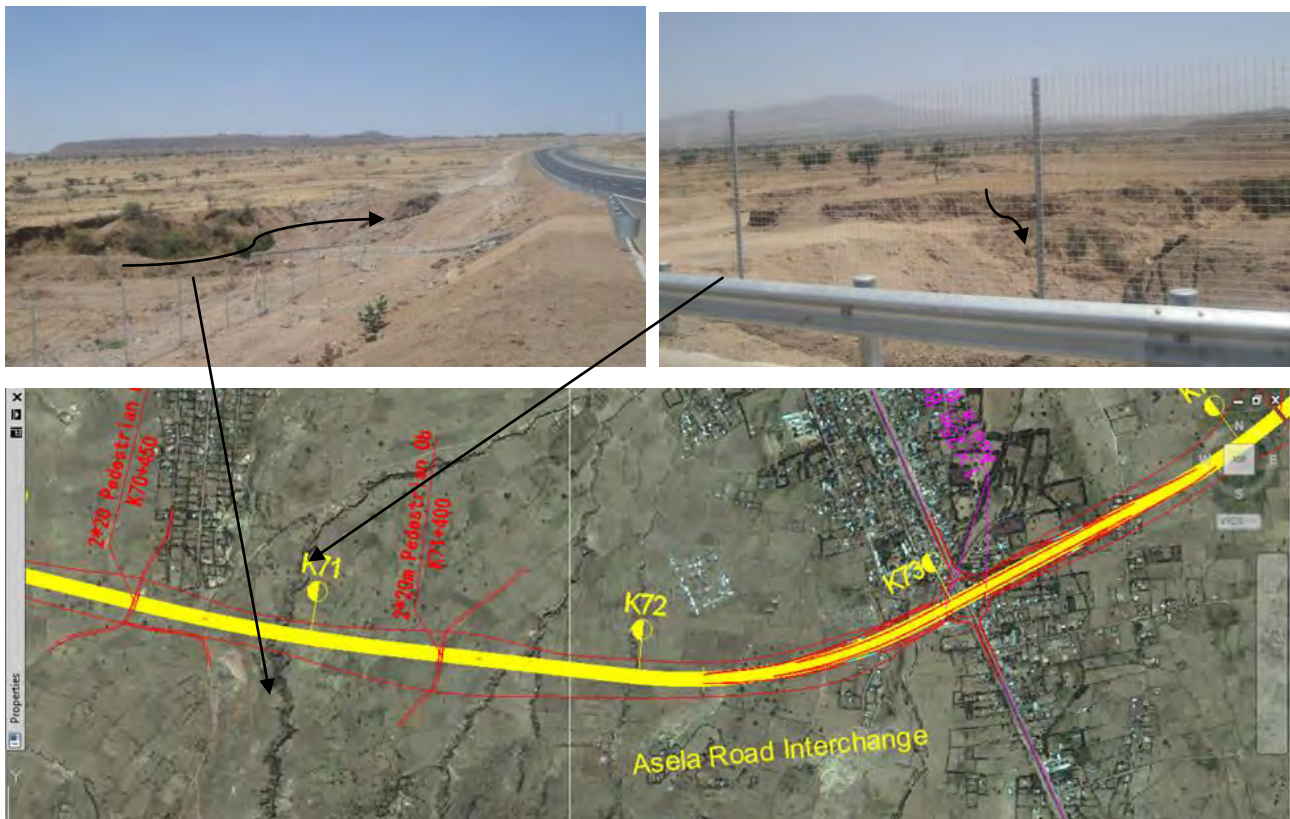


Figure 2.5a; Severe eroded gullies right at the side of the Express (Route of Express way highlighted yellow)¹

Source: ERCC

¹ The Aerial photo taken at 2011 is found to be more illustrative of the Express way while the pictures at different locations are up to date.

FIELD INVENTORY PHOTOS



Figure2.5b; Severely eroded gullies near the Express way. (Route of Express way highlighted yellow)¹

Source: ERCC

¹ The Aerial photo taken at 2011 is found to be more illustrative of the Express way while the pictures at different locations are up to date.

FIELD INVENTORY PHOTOS



Figure 2.6: Examples of efforts to stabilize cut batters of the Express



Figure2.7: Example of a fill batter road side easily blending with the surrounding landscape

FIELD INVENTORY PHOTOS



Figure 2.8a: Examples of cut batters of the Express still not stabilized.(Route of Express way highlighted yellow)¹

Source: ERCC

¹ The Aerial photo taken at 2011 is found to be more illustrative of the Express way while the pictures at different locations are up to date.

FIELD INVENTORY PHOTOS

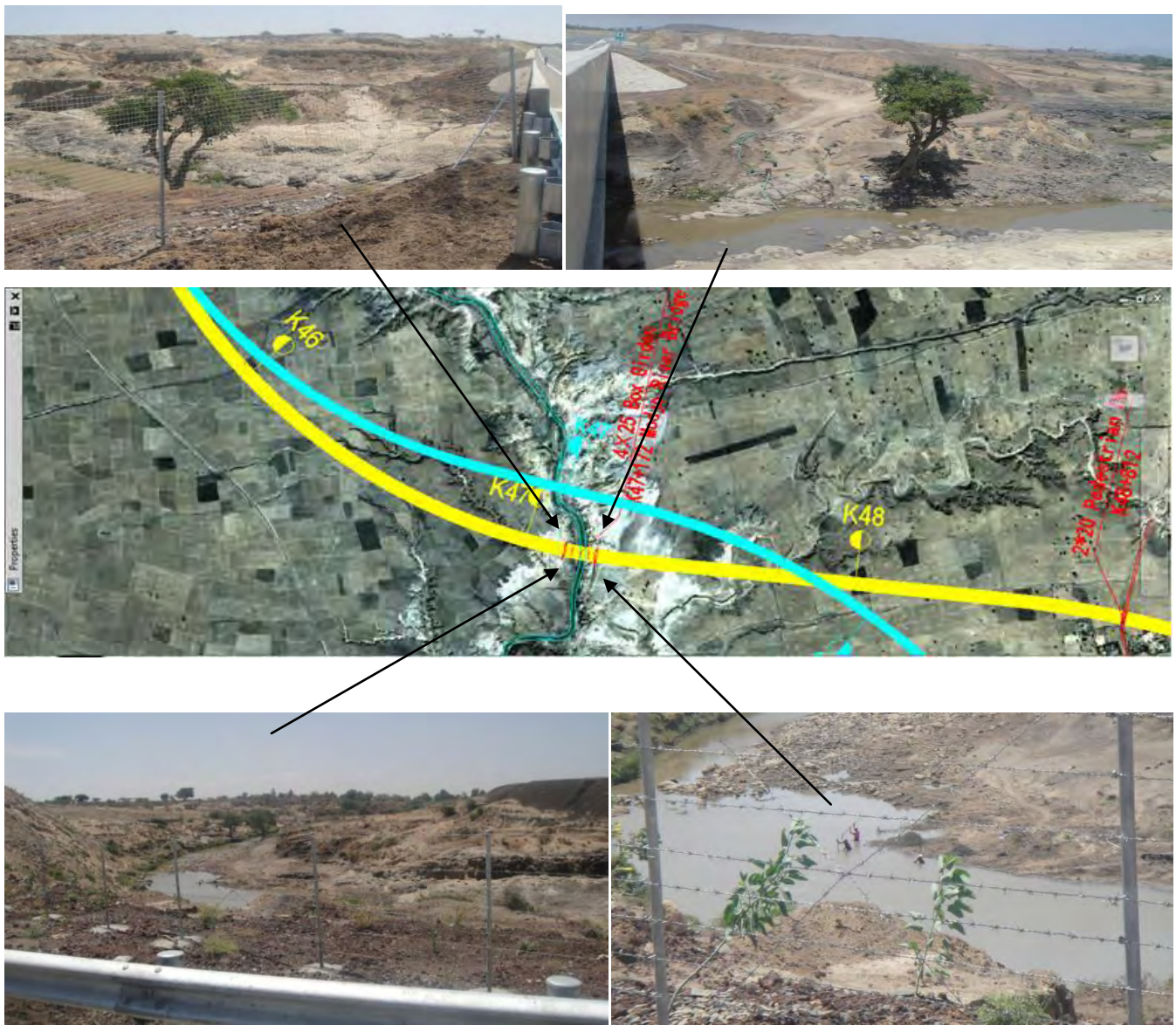


Figure 2.8b :The above figure shows Modjo river and its surrounding landscape at around 48 kms of the Express way. (Route of Express way highlighted yellow)¹

Source: ERCC

¹ The Aerial photo taken at 2011 is found to be more illustrative of the Express way while the pictures at different locations are up to date.

FIELD INVENTORY PHOTOS



Figure, 2.9 : Photos showing Modjo river sustaining within such degradation of the surrounding environment while streams and rivers dry out seasonally leaving eroded gullies behind

FIELD INVENTORY PHOTOS



Figure 2.10; Goliya river and its surrounding landscape at around 55 kms of the Express way. (Route of Express way highlighted yellow)¹ Source: ERCC.

¹ The Aerial photo taken at 2011 is found to be more illustrative of the Express way while the pictures at different locations are up to date.

FIELD INVENTORY PHOTOS



Figure 2.10; Condominium houses located within 3 kms of the Express way. (Route of Express way highlighted yellow)¹

Source: ERCC

¹ The Aerial photo taken at 2011 is found to be more illustrative of the Express way while the pictures at different locations are up to date.

SAMPLE PHOTOS OF OPERATIONAL FUNCTION



Figure5.1a: Operational function- accommodation for lay-bys' and information ahead.



Figure 5.1b)



Figure 5.1.c)

Figure5.1b: Operational function- accommodation for sign posts and barrier from external intrusion.

Figure5.1c: Operational function-Access control

GEOLOGICAL MAP OF THE STRECTH

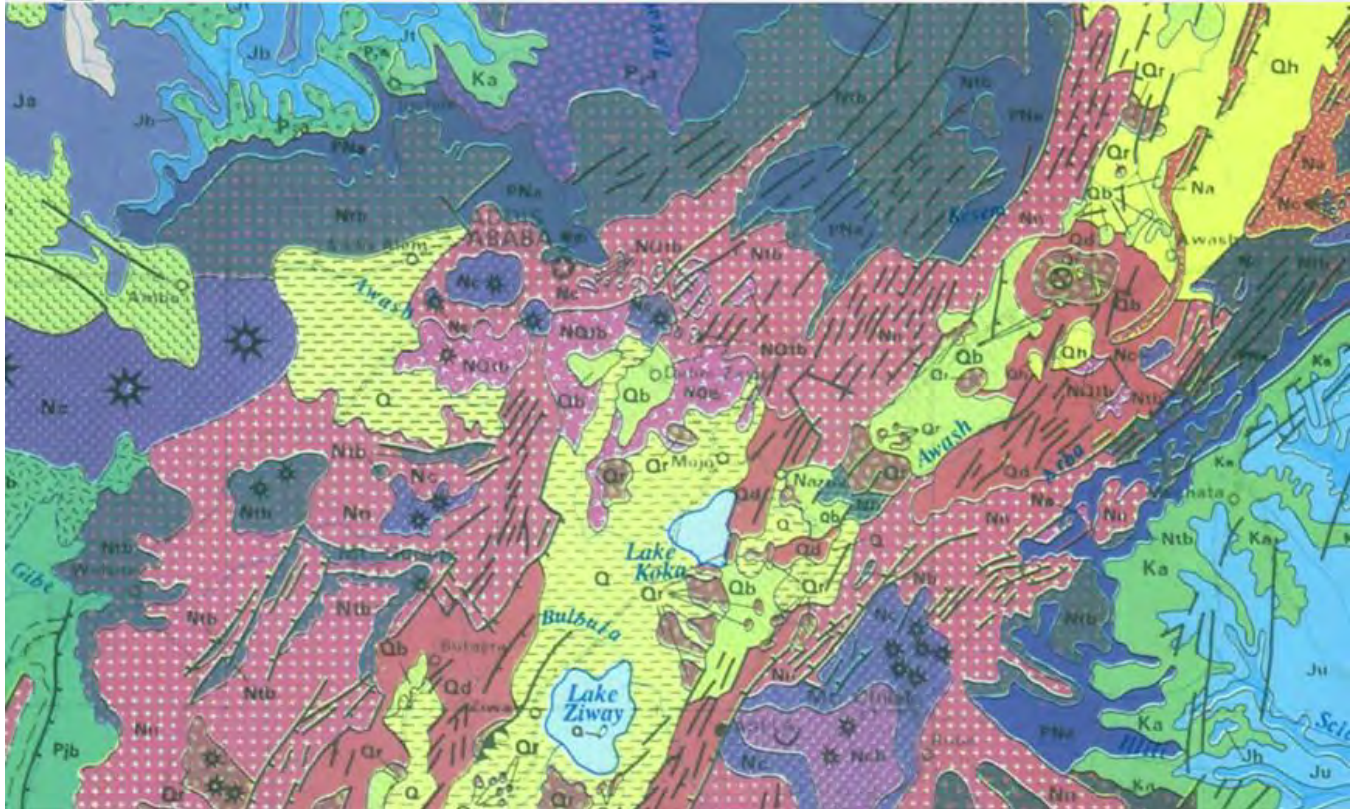


Figure 6.5: Geological map of the project stretch

Source: ERCC

ANNEX-2

ACCURACY ASSESSMENT

GPS used for verification of the existing land use land cover. After digitizing and classifying, topographic points selected and taken during field observation are used to cross check and validate the ground truth and reclassify the land use land cover map again on ERDAS.

Point #	Name	X	Y	Class	Reference
1	ID#1	0.000	0.000	0	0
2	ID#2	505395.000	962494.000	13	13
3	ID#3	505783.000	962111.000	13	13
4	ID#4	507789.000	959736.000	13	13
5	ID#5	511447.000	955141.000	13	13
6	ID#6	512822.000	953760.000	3	15
7	ID#7	514989.000	951820.000	13	13
8	ID#8	515760.000	949079.000	3	3
9	ID#9	515714.000	949101.000	3	3
10	ID#10	519709.000	947487.000	15	15
11	ID#11	516578.000	949265.000	3	3
12	ID#12	515534.000	950654.000	15	15
13	ID#13	512696.000	953839.000	13	15
14	ID#14	505068.000	962934.000	13	13
15	ID#15	515800.000	949025.000	3	3
16	ID#16	517418.000	948983.000	3	3
17	ID#17	518698.000	945514.000	15	15
18	ID#18	521350.000	945514.000	15	15
19	ID#19	522810.000	944374.000	15	15
20	ID#20	523319.000	943687.000	15	15
21	ID#21	525355.000	940760.000	3	15
22	ID#22	526233.000	940560.000	13	15
23	ID#23	528035.000	939872.000	3	3
24	ID#24	529642.000	939694.000	15	15
25	ID#25	534039.000	944120.000	3	3
26	ID#26	504098.000	963348.000	13	13
27	ID#27	504058.000	963366.000	13	13
28	ID#28	496207.000	973253.000	13	13

Figure 6.1: Ground truth assessment for land use land cover

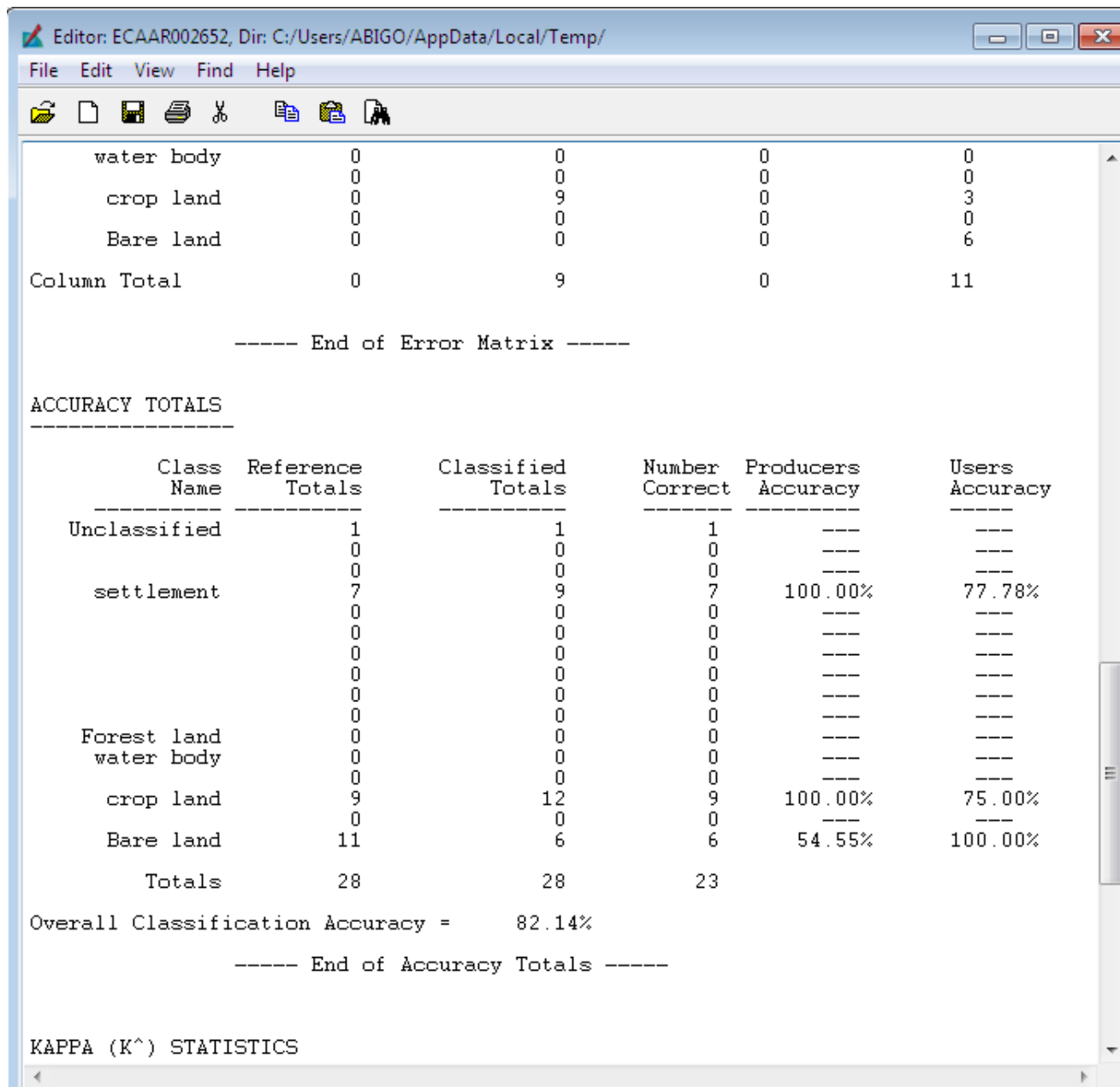


Figure 6.2: Land use land cover map with an accuracy total of 82.14% where output is acceptable.

CALCULATIONS



Figure 6.3: vector calculation to estimate area of the study area.

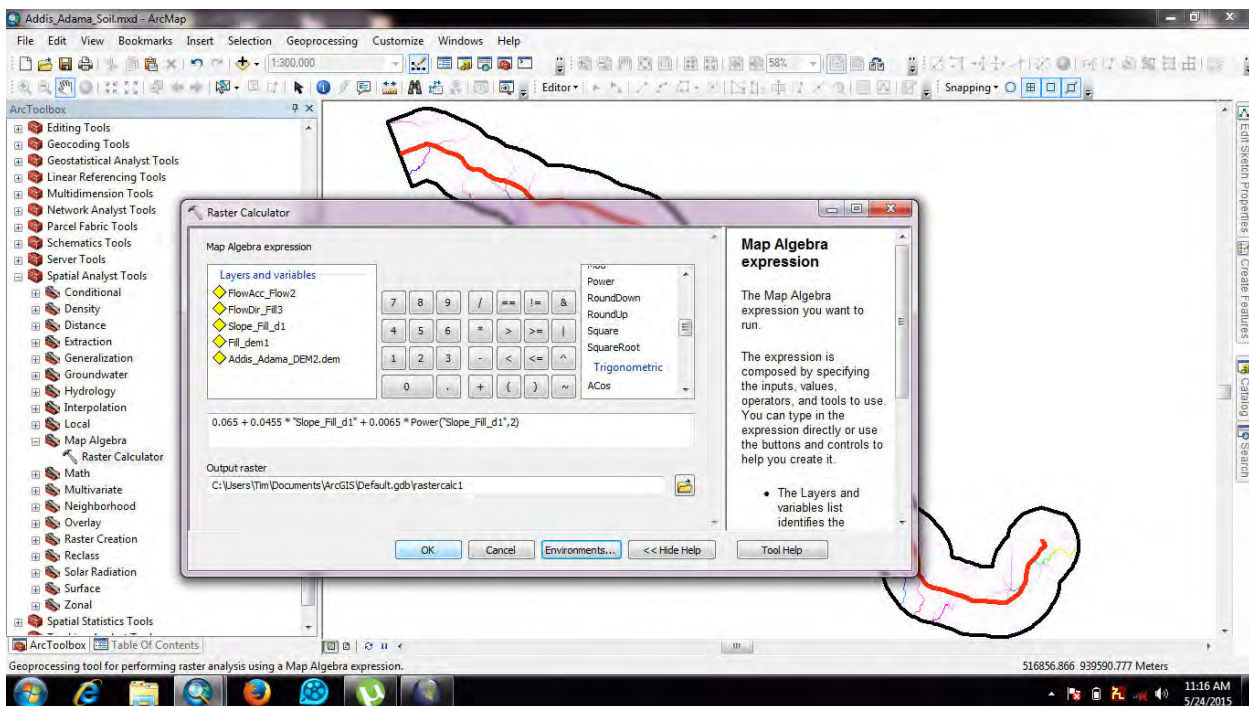


Figure 6.4 : Raster calculation for the topographic factor.



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ASSESSMENT OF SOIL EROSION THREATS ON ENVIRONMENTAL FUNCTIONS FOR ROAD SIDE DEVELOPMENT: the case of ADDIS ADAMA EXPRESS WAY

A thesis submitted to the Ethiopian Institute of Architecture, Building Construction and City Development (EIABC) in partial fulfillment of the Degree of Masters of Science in Environmental Planning and Landscape Design.

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ASSESSMENT OF SOIL EROSION THREATS ON ENVIRONMENTAL FUNCTIONS FOR ROAD SIDE DEVELOPMENT: the case of ADDIS ADAMA EXPRESS WAY

MASTER OF SCIENCE IN ENVIRONMENTAL
PLANNING AND LANDSCAPE DESIGN

Master's Thesis

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ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES.

This is to certify that the Thesis prepared by Temnit Hadera Gebremedhin, Entitled: Assessment of Soil erosion threats on Environmental Functions for Road side Development: the case of Addis Adama Express way, and submitted in partial fulfillment of the requirements for the degree of Master of Science in Environmental Planning and Landscape Design complies with the regulation of the University and meets the accepted standards with respect to originality and quality.

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DECLARATION

I, the undersigned, declare that this thesis entitled” **ASSESSMENT OF SOIL EROSION THREATS ON ENVIRONMENTAL FUNCTIONS FOR ROAD SIDE DEVELOPMENT: the case of ADDIS ADAMA EXPRESS WAY**” is my original work and has not been presented for any degree in any university and all the sources of materials used for the thesis have been duly acknowledged.

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Signature: -----

Date of submission: -----

CERTIFICATION

Here with I state that TEMNIT HADERA has carried out this research work on the topic entitled “**ASSESSMENT OF SOIL EROSION THREATS ON ENVIRONMENTAL FUNCTIONS FOR ROAD SIDE DEVELOPMENT: the case of ADDIS ADAMA EXPRESS WAY**” under my supervision and it is sufficient for submission of the partial fulfillment for the award of MSc.,Degree in Environmental Planning and Landscape Design.

Dr.GETE ZELEKE

Signature: -----

Date of submission: -----

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First of all, I give thanks to the glorified GOD, who has created me and provided me His Good Wills in all my activities. Secondly, I thank my family in general and my husband, to Habtamu Mekonnen, in particular who has contributed the lions share in the success of my life so far.

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ACRONYMS

CCCC	China Communication and Construction Corporation
CRGE	Climate Resilient Green Economy
ERA	Ethiopian Road Authority
ERCC	Ethiopian Road Construction Corporation
EPA	Environmental Protection Agency
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization
GPS	Global Positioning System
IMP	Impact Mitigation Procedures
MEF	Ministry of Environment and Forest
ROW	Rights-of-way
RAP	Resettlement Action Plan
RUSLE	Revised Universal Soil Loss Equation
SLT	Soil Loss Tolerance

ABSTRACT

A developed road side should provide operational, auxiliary, visual and environmental functions that are dependent on the biophysical and spatial nature and status of the surrounding landscape. It is imperative that major environmental components such as air, water, soil, fauna and flora be preserved and integrated within a road network to sustain ecological balance of the environment and service demand of the road. One of these components the soil in particular, is overlooked for its decisive role to ecologically integrate and sustain a road network for its designed years of service. Areas exposed to sever soil erosion leading to loss of water bodies and land degradation within the rights-of-way and a possible extension beyond for their critical and context sensitive objectivity, needs to be planned, designed, constructed and maintained for vegetation management and environmental preservations and remediation.

In this research, soil erosion is raised as one of the critical and context sensitive environmental problem resulting in loss of minor water bodies and land degradation within the study area threatening sustainability of the Express way

The problem is identified and assessed using field inventory and subsequent spatial analysis of relevant road side contextual features or topographic appearances' by implementing RUSLE Model in Arc GIS. The contextual features or parameters are rated or weighted to pin point the extent of soil erosion and propose remedial measures further.

In addition, the research outlines the need for

- ❖ Conventional definition and extent of road side development*
- ❖ A conceptual frame work for natural resource preservation and landscape management of municipal developments, in particular the Express way, for context sensitive, critical planning and development.*
- ❖ identification of road side functions and values, prioritizing relevant contextual data on natures' inventory within and beyond rights-of-ways of the Express way*
- ❖ Assessment models with analytical procedures to support integrated decision making and policy level considerations of road side development.*

Moreover, Federal and Regional policies and guidelines should be declared officially and implemented while planning, designing, constructing and maintaining non- traditional road side development.

KEY WORDS: *Context sensitive road side development, Environmental Function, Road side definition, Road side extent, , Soil erosion, RUSLE model,*

1. INTRODUCTION

1.1 BACKGROUND OF THE STUDY

“Sustainable roadsides are those roadsides that are designed and maintained with the intent of integrating successful operational, auxiliary environmental and visual functions with low life cycle costs.”(WSDOT, 2014).

Soil and vegetation are components of a natural resource, the land, where environmental interventions and landscaping are carried out. These environmental functions are mainly founded upon the soil as the solid matter on the earth surface where the Lithosphere, Biosphere, Hydrosphere and Atmosphere interface.

The importance of soil is underestimated in an urban or city environment. Soil lying beneath the feet of urban dwellers-it nourishes garden and park lands, support building foundations, underlies transport corridors and is often used as a sink for effluent and waste disposal. It is also a medium in which vegetation grows, often to remediate sites which have been scarred by change in the landscape.”(Hezelton, P. and Murphy, B., 2011,pg.4.)

Failure of the soil to function as expected can have a significant effect on the urban environment, resulting in serious impacts including damage to buildings and roads, land slide, poor water quality, soil contamination, dry land salinity and degraded ecosystems. To prevent further degradation and loss of productive soil resources, and to achieve environmental quality and hazard protection in cities, professional need to interact with all stakeholders and policy makers to ensure that the potential problems of working in urban soil can be assessed and managed sustainably. (Hezelton, P. and Murphy, B., 2011)

It is therefore, imperative to look into the soil in particular as a distinct entity upon which Environmental resource management and landscaping of road side development is realized on the Addis-Adama Express way. Because the sustainability of the road and its road side functions will be dependent on how well the soil within the highway buffer is managed.

1.2 OBJECTIVES

1.2.1 GENERAL OBJECTIVE

The major objective of the study focuses on assessment of the soil erosion threat on environmental functions of the developed road side of ADDIS-ADAMA Express way and suggests possible mitigation measures.

1.2.2 SPECIFIC OBJECTIVES

- Assessing study area vulnerability to soil erosion
- Suggesting potential measures to improve environmental functions of the Express way.
- Raising awareness of key stakeholders on the importance of natural resource management and landscaping of road side development for major road corridors

1.3 METHODS AND MATERIALS

The study attempts to show the extent of soil erosion and its possible impacts as well as the vulnerability of the surrounding landscape of the Addis Adama Express way to soil erosion threats. Thus an effort is made to utilize the Revised Universal Soil Loss Equation (RUSLE) Soil erosion model to assess the extent of erosion and its potential threats to the corridor.

In this research both primary and secondary data were used. Secondary data (satellite image, aerial photo, metrological data and literature review) were collected and used for the analysis. Moreover, key informant interviews and field observations using Global Positioning System (GPS) is used to generate primary information regarding the road side management and to assess land use land cover situations and soil loss vulnerability signs. The field observations were also used to verify the accuracy of the land use land cover classification made using remote sensing techniques on the ground.

Data analysis and processing were done by digitizing, calculating and classifying the necessary information of each thematic layers using ArcGIS 10.2 software.

Primarily the problem was identified and the scope of the research study and the extent of the study area were defined. The soil within the surrounding landscape, as a foundation where environmental management and landscaping are based upon, is highly exposed to erosion letting further land degradation threatening the sustainability of the Express way. Terrains topography, soil type, land cover type, land management practice and amount of rainfalls are the factors influencing the amount of erosion in the study area and served as parameters for RUSLE Model. The basic methodological rule followed in RUSLE is shown in the flow chart below on Figure 1.1, data needs, gaps and sources to run RUSLE model is also given on Table 1.1.

DATA	METHOD OF INPUT	DATA SOURCE
Rain fall data	Used for calibration of Model	National Metrological agency
Soil type classification	Used for calibration of Model	FAO. Soil classification shape files
Location map	Used for calibration of Model	ERCC
Land use land cover map	Classified from satellite image	Google earth image rectified by personal field observation through GPS
ASTGTM satellite tiff images	DEM	USGS/EROS

Table 1.1: Identified data types and possible sources

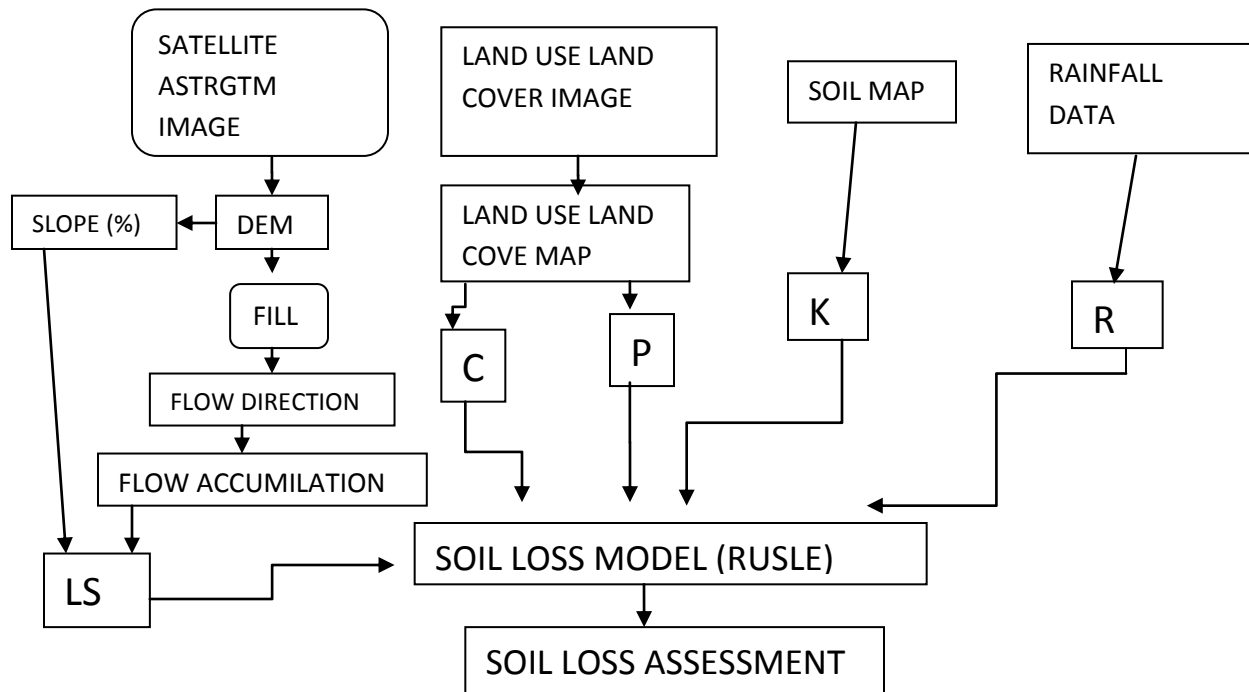


Figure 1.1: Flow chart showing the methodology used for soil loss assessment.

In the end, Raster calculation analysis of all parameters using map algebra is carried out to identify and sort areas with erosion susceptibility.

Moreover, literature reviews on trends of road side development and landscape management of the developed nations is studied. Interviews were held with focal persons at Ministry of Environment and Forest (MEF) and Ethiopian Roads Authority (ERA) to pinpoint the existence and practicality of such developments in Ethiopia.

1.4 SIGNIFICANCE OF THE STUDY

This research is important in showing the relevance of ecologically integrated road side and its surrounding landscape development by creating a common understanding regarding the extent of road side environmental management and landscaping. It also shows the need to address context sensitive environmental problems and raise sustainable solutions while executing major developmental project.

1.5 LIMITATIONS OF THE STUDY

This study focuses only on assessing extent and potential threats of soil erosion on Addis-Adama express way and its road side environmental functions. It doesn't address all other possible threats on the express way and its environmental functions. Previous studies on Environmental functions of roadside development of roads was unavailable and there was financial limitation to use Remote sensed images of greater accuracy such as IKONOS-5 meters Digital Elevation Model- which can help with further sensitivity analysis or calibration of model.

1.6 THESIS LAYOUT

The thesis is composed of six separate chapters. The first chapter gives introduction on the background of the problem, objectives of the research study, the method of study, its significance and limitation and layout of the thesis in general. In the second chapter, location, scope, description and existing land use land cover of the study area is described.

Chapter three covers literatures on the concept of Road side development in particular the development of Environmental function giving emphasis to the relevance of soil conservation within the urban environment. In the fourth chapter, RUSLE model simulation procedures and results to identify extent of erosion within the road side of the Express way is presented. Later on, results and discussions concerning the outcome of RUSLE assessment and a discussion on the definition and trends of road side development in Ethiopia after interviews with selected focal persons from MEF and ERA offices is presented in Chapter five.

Finally, conclusions on the extent of soil erosion within the road side of the study area and f recommendation measures on soil conservation as a means to attain sustainable environmental functions of a road side development are discussed in chapter six. Different photos and additional information are presented in the annexes.

2. THE STUDY AREA

2.1 LOCATION OF THE STUDY AREA

Addis Ababa-Adama Expressway is located at south-east of Addis Ababa City. It connects Addis Ababa, the capital city of Ethiopia, and another important city Adama and mainly goes through Dukem, Bishoftu and Modjo cities (See Figure 2.1). It will be the first expressway of Ethiopia. The route length is 78.4km, and is constructed as a dual three-lane expressway standard, with design speed of 100~120km/h and sub-grade width of 31.0m.

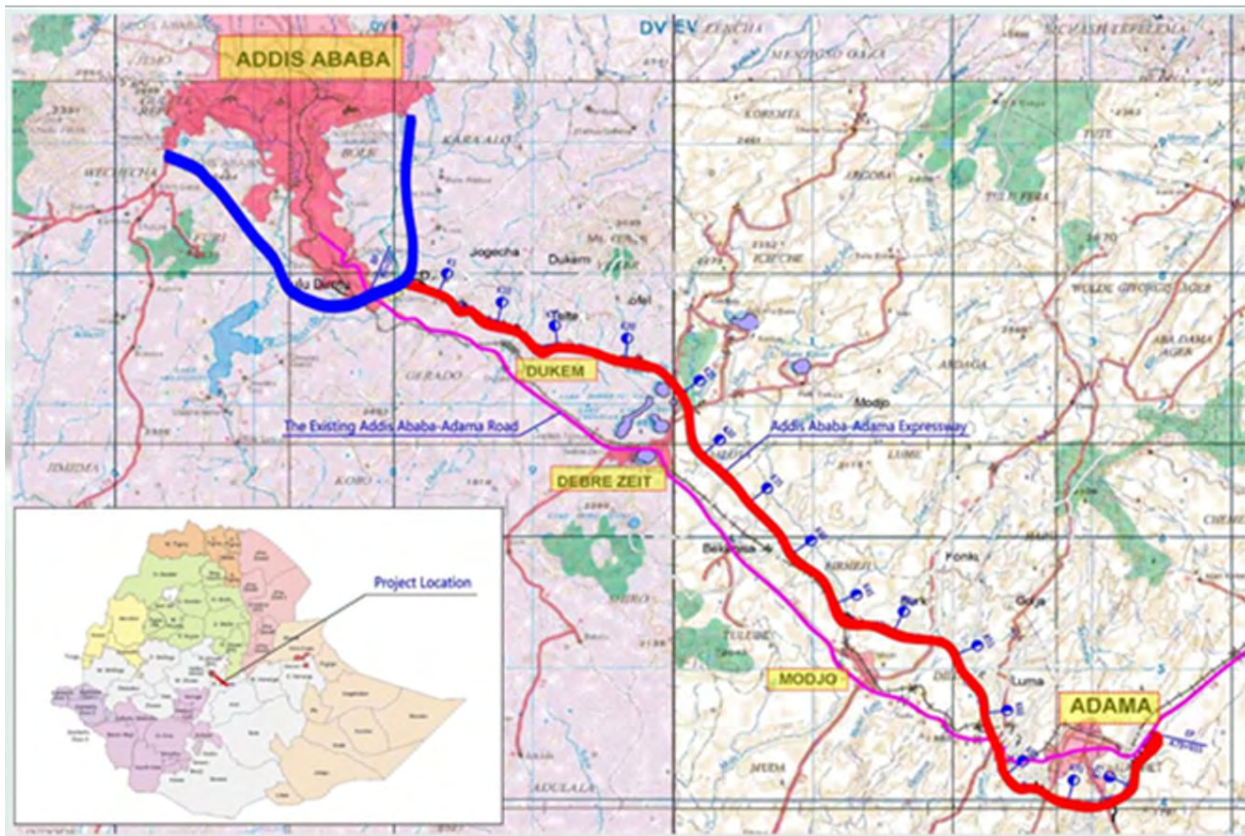


Figure 2.1 Direction of Express way

It is located in Central part of Ethiopia in Oromia Regional State starting from Tulu Dimtu, 13 kilometers south-east of Addis Ababa City. The mainline of the expressway follows 2.8 Kilometers on the proposed future Eastern Outer Ring Road of Addis Ababa. The Expressway proceeds in a southeast direction, passing to the east of Dukem Town, Bishoftu City, and Modjo Towns crossing the existing Addis Ababa – Adama at approximately 62 Km to bypass Adama on southern side. The expressway terminates to the east of Adama, connecting with the existing Adama – Awash trunk road (Figure 2.1).. It is being constructed by china communication construction company (CCCC).

2.1.1 SPATIAL SCOPE

The spatial scope of the study area is confined to the immediate road side and vicinity of about 2.5 kms right and left of the Express way which made a totality of 5 kilometers buffer. The Addis-Adama Express way is one of its kinds in Ethiopia where roundabout interchanges, clover leaf interchanges and overpass and underpass bridges are constructed within the road way requiring major natural resource conservation, management and landscaping. The means to fulfill these requirements is a road side development and landscape management.

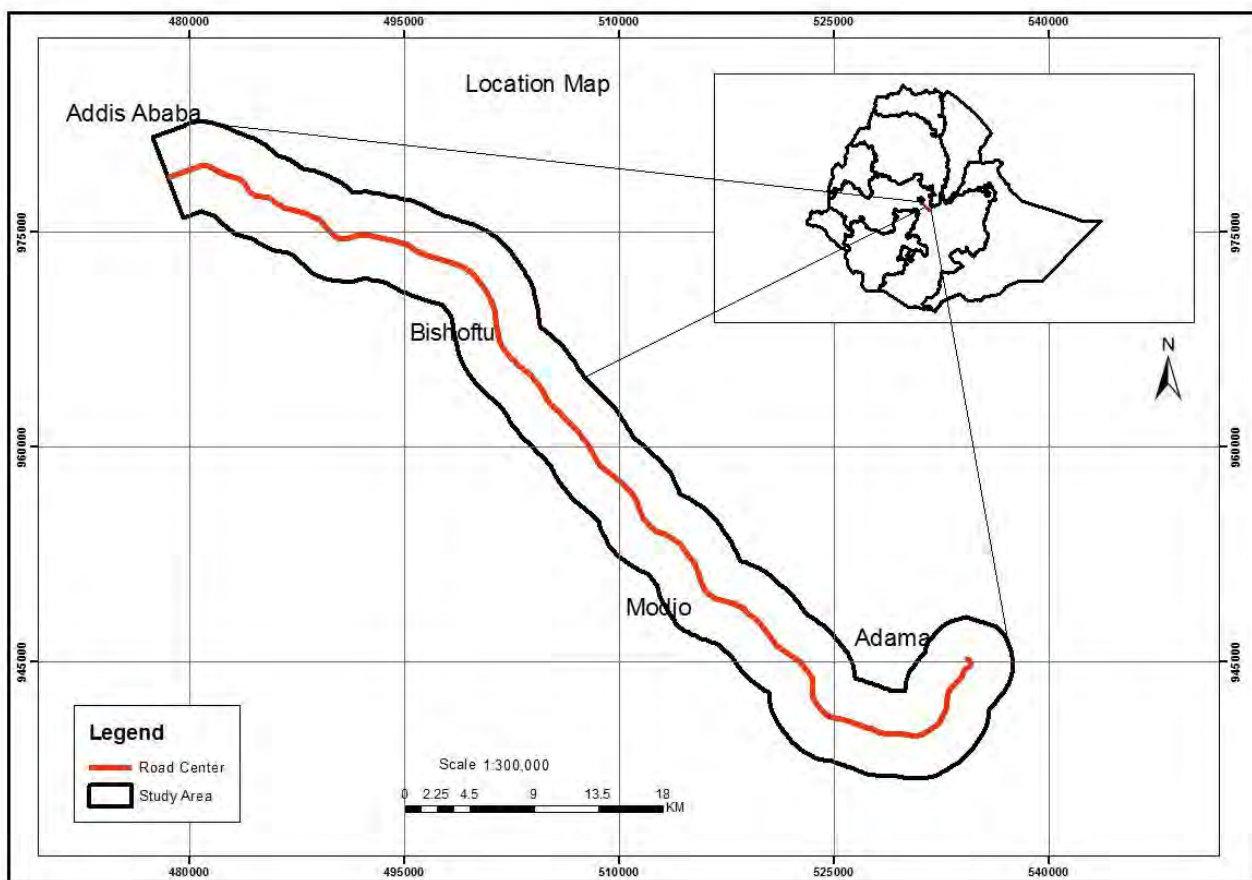


Figure 2.2: Study area-the express way and a 5kms buffer area of its surrounding landscape.

2.1.2 THEORETICAL SCOPE

The research is confined to promoting integrated and ecologically sustainable designs for road side development including the immediate vicinity supported by directives and legislations considering visual resource assessment,

management and landscaping for major primary corridor projects such as the Addis-Adama Express way. The theme of the research may extend and apply to other major development projects such as condominium housing.

2.2 DESCRIPTION OF THE STUDY AREA

The road side and surrounding landscape may commonly be understood to share more or less similar geology and geomorphology with that of the road corridor. ERA has illustrated, in its geotechnical report, that the Express way traverses various types of geological formation. It is dominated by volcanic rocks with Alluvial and Lacustrine deposits at some short stretch. Main geological formations along the Express way are composed of:

Nn = Nazret Series: Ignimbrite, tuffs, ash flows, rhyolite flows, domes and trachyte;

NQtb = Bishoftu Formation: Alkaline basalt and trachyte;

Qb = Alkaline basalt

Q = alluvial basalt and lacustrine deposits: sand, silt and clay;

Nc = Trachyte, Trachyte-basalt, per alkaline rhyolite with subordinate alkaline basalt. (ERA Geotechnical report, 2010)

The highway route is covered by volcanic rocks of Quaternary to Tertiary period, with little deposit of Quaternary. The Quaternary to Tertiary volcanic rocks are shown to comprise the Adama Series (Nn), alkaline olivine basalt (Qb) and Bishoftu Formation (NQtb). Bishoftu Formation (NQtb) and Adama Series (Na) rocks are the predominant rock units between Tulu Dimtu and Bishoftu with minor alkali Olivine basalt (Qb). The Bishoftu Formation mainly consists of basalt and trachyte while the Adama Series rocks include ignimbrite, pumice, ash and rhyolite with rare intercalations of basaltic flows (ERA Pavement design report, 2010). The geological map of the study area is presented as figure 6.5 on Annex 1.

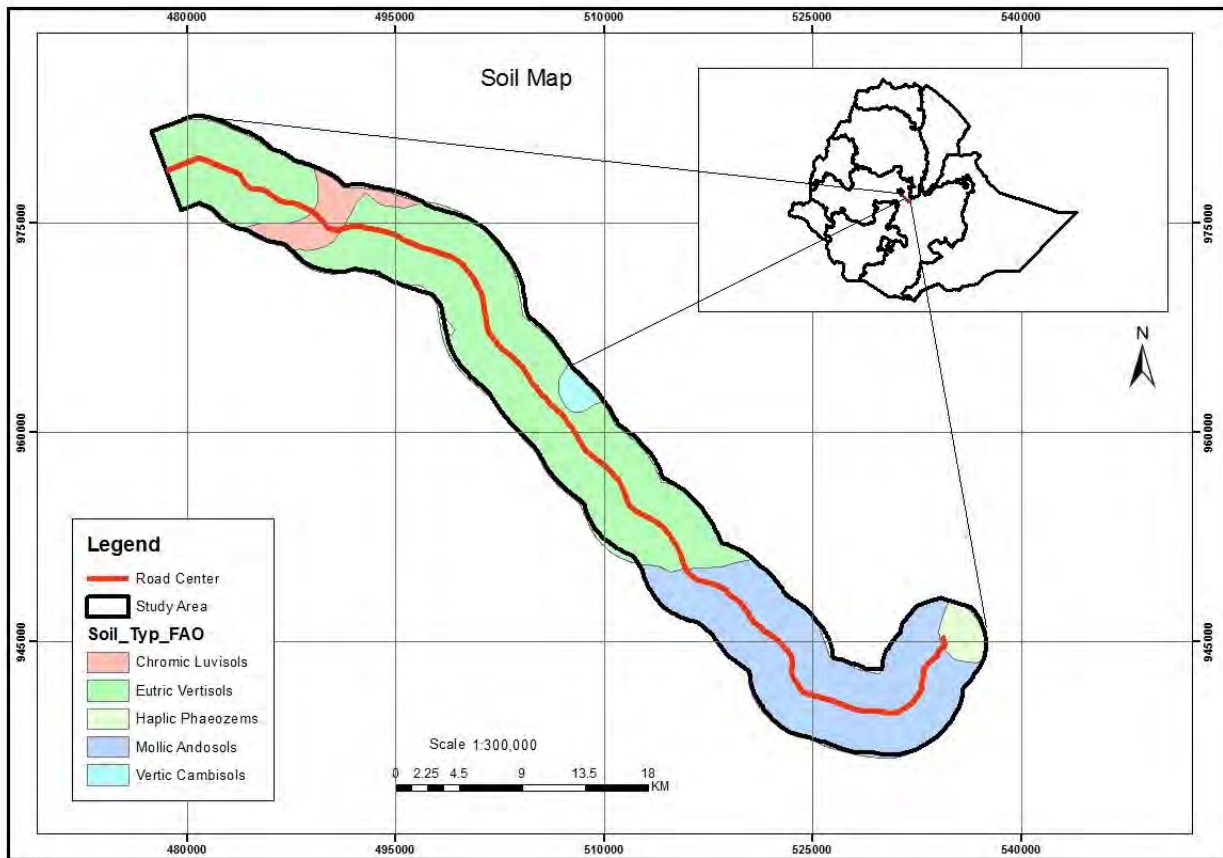


Figure 2.3: Soil type classes of the study area according to FAO.

2.2.1 FIELD INVENTORIES ON CURRENT STATE OF NATURE AND SURROUNDING LANDSCAPE

About two-thirds of the road stretch is covered by a sedimentary deposit of black cotton soil with thickness of 1~3 meters or so. The topography of the highway route is characterized by rolling and flat terrain and dendrite drainage pattern(ERA Geotechnical report,2010). With such topography the area is exposed to severe soil erosion, land slid at the uphill and flooding at the flat terrain. The road side is covered with few vegetation and a majority of bare lands exposed to severe erosion which may impose a serious threat to the Express way sustainability. The surrounding landscape is composed of natural and sediment deposits comprising wind-blown materials. Typically it includes a black earth with uniform dark brown or black clay soil with approximate depth

of 50-100 cms depth where seasonal swelling and cracking during the wet and dry seasons takes place and reddish sandy soil lying underneath where ever exposed.

Severely eroded gullies right at the side of the Express way are observed. In its current state, the soil is highly susceptible to detachment and transportation by erosive agents such as wind and water. In addition the soil contribution in capturing carbon dioxide from adjacent traffic by sequestering carbon emissions to the environment and reduce local temperature rise, is diminished. Regarding roadside slope stabilization a promising effort has begun but not efficient enough to control slope erosions which impose serious threats to the road (see further photos on figure 2.5a& 2.5b on Annex 1).



Figure 2.4a: Pictures of eroded gullies

The Express way navigates mainly through farmlands and bare lands with settlements, quarry sites and minor water bodies. The Dengora, Gogecha, Dukem, Bekenisa, Modjo and Golja streams cross the Express way at different points. However, the water flow in these streams fluctuates seasonally where most streams dry-up during the dry season.. This is partly related to lack of vegetation buffer and high level of degradation of the surrounding landscape which results the loss of rainfall as runoff with very little time to infiltrate and recharge the ground water. (See further figures 2.8, 2.9 and 2.10 on Annex 1).



Figure 2.4b: Pictures of a minor water body or stream

2.3 LAND USE LAND COVER

The land use land cover for the study area is categorized broadly to the following five major classes: i) settlements, ii) water bodies including minor streams and river, iii) crop lands or agricultural lands, iv) wood lands and v) bare lands. These land use land cover classes were defined using remote sensing and GIS supported with field observation using GPS to verify actual land use or land cover class on ground (see Figure 6.1 in Annex 2 for GPS points used for verification of land use and land cover classification).

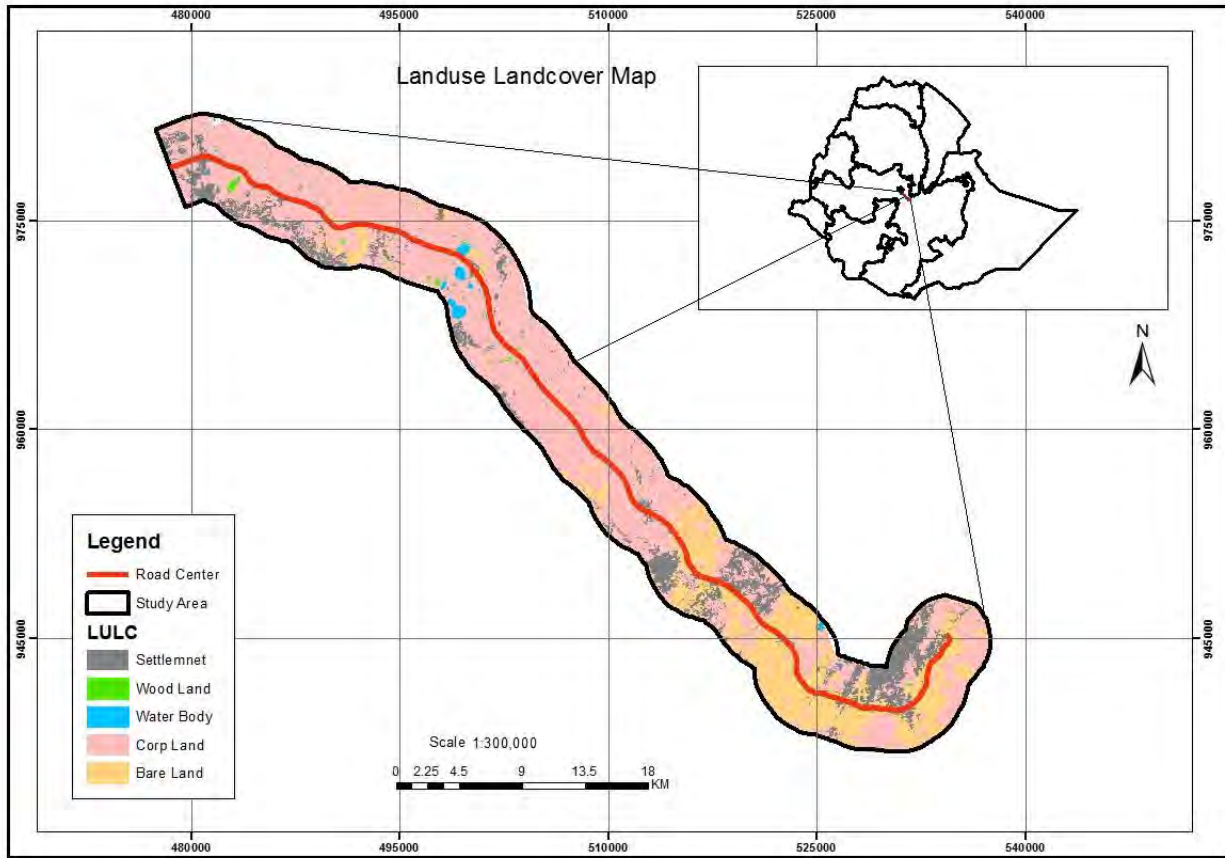


Figure 2.5: Land use land cover map of the study area.

LAND USE LAND COVER	AREA IN HECTAR (ha)	AREA IN PERCENTAGE
SETTLEMENT	6,890.6	14.3%
WOOD LAND	799.381	1.659%
WATER BODIES	800.19	1.66%
CROP LAND	27,771	57.6%
BARE LAND	11,902	24.7%
Σ of Area	48,163.2	100%

Table 2.3: Proportion of existing land use land cover types of the study area.

3. LITRATURE REVIEW

3.1. ROAD SIDE AND ITS DEVELOPMENT

The area outside the travelled way and may extend to elements outside the right-of-way boundaries. It includes unpaved median strips and auxiliary facilities such as rest areas, road side parks, view points, heritage markers, pedestrian and bicycle facilities, wet lands and their associated buffer areas, storm water treatment facilities, parks and ride lots, quarries and pit sites, (WSDOT,2014).

Roadsides are an important component of highway design, operation, and maintenance because of the Operational, Environmental, Visual and Auxiliary functions they provide. Properly designed and maintained, roadsides complement the functions of the roadway, integrate the roadway facility into the surrounding landscape and provide a positive psychological effect on vehicle occupants, (WSDOT,2014)

“The road side development design incorporates visual aspects, functional needs, maintenance and sustainability, and environmental goals related to visual management and landscape design. Road side is an area outside the traveled way and may extend to elements outside the right- of- ways boundaries. It includes unpaved median strips and auxiliary facilities such as rest areas, road side parks, viewpoints, heritage markers, pedestrian and bicycle facilities, wetlands and their associated buffered areas, storm water treatment facilities, parks and ride lots, and quarries and pit sides. Road side development encompasses context sensitive and sustainable design and installation of landscape and hardscape elements in the right- of- way to integrate the transportation facility into the surrounding environment. Road side development focuses on visual resource management that assesses, protect, and mitigate impacts of highway projects to both cultural and natural resources.” (State of Oregon, 2006, pg. 6)

Road side development encompasses context sensitive and sustainable design and installation of landscape and hardscape elements in the right-of-way and beyond, to integrate the transportation facility into the surrounding environment where visual resource management plays a great role in the development by assessing, protecting and mitigating impacts of high way projects to natural resources. (State of Oregon, 2006)

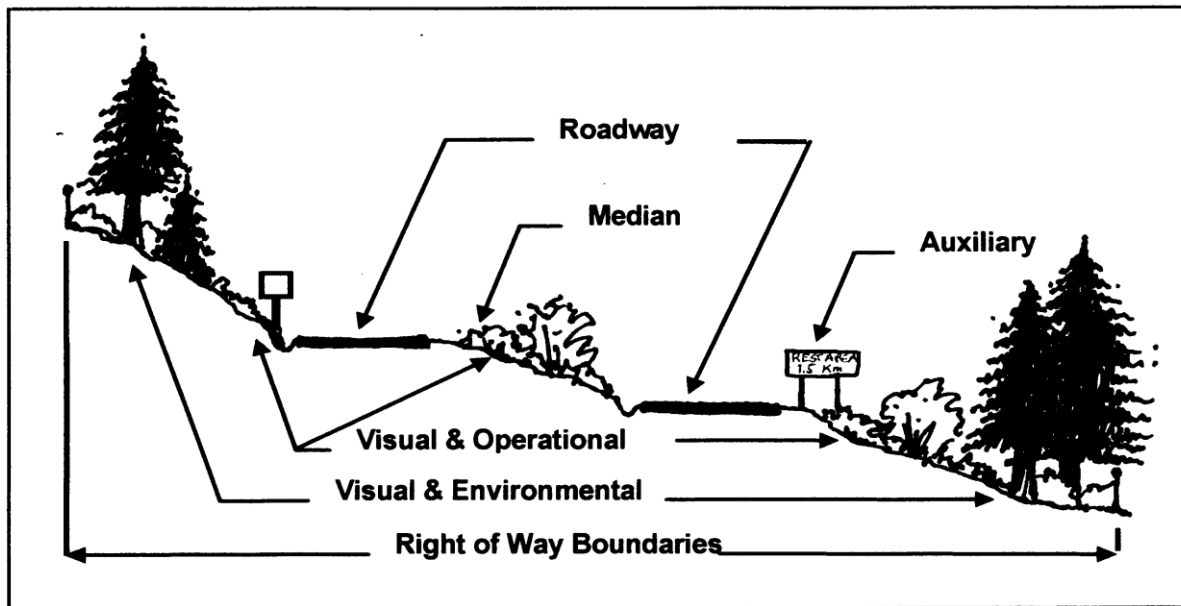


Figure 3.1 Road side functional areas example

Source;WSDOT,2014

These visual resources are explained as;

- Landforms: such as mountains, hills, plateaus, valleys, beaches.
- Water resources: such as rivers, lakes, oceans, marshes, wetlands.
- Vegetation: such as grass lands, parks, forests and croplands.
- Human development: such as highways, structures, lighting, fencing and guardrails and they create stimuli upon which actual visual experience is based.

State of Oregon has also showed that there are different projects that may trigger requirement for road side development and visual resource management which are listed below.

- Where there is greater disturbance to the natural and built landscape, the greater will the need be for road side development that impacts visual resources.
- For State or Federal scenic highway or Tour route, there may be requirements for visual impact assessment and related landscaping.
- When project affects river segments or lakes, consideration of visual impact and landscaping is necessary.

- When a project is within or adjacent to Federal or State or Local parks and recreation or conservation lands (includes National historic and scenic Trails, wildlife sanctuaries, refuge and preserves, ‘beech lands’), coordination with those agencies will be necessary.

When a project includes a new or relocated roadway alignment or a new interchange, major cuts and /or fills, any new major structures such as bridges, retaining walls etc., visual resource assessment and landscaping will be considered.

<i>FUNCTIONS</i>	<i>EXAMPLES</i>
<i>Operational functions</i>	<i>Those functions that provide safe and multiuse roadsides. Operational functions include access control, and providing recovery areas and sight distances with accommodations for signs and utilities, and snow storage. The Design Manual remains the primary guidance for operational design guidance.</i>
<i>Environmental functions</i>	<i>Those functions that protect and enhance our natural and built surroundings. Environmental functions include water quality preservation, protection and improvement, storm water detention and retention, wetland and sensitive area protection, noxious weed control, noise control, habitat protection, habitat connectivity, air quality improvement and erosion control.</i>
<i>Visual functions</i>	<i>Those functions that are designed and experienced primarily from a visual perspective. Visual functions promote a positive quality of life and are integral to operational, environmental, and auxiliary functions. They include positive guidance and navigation, distraction screening, corridor continuity, roadway and adjacent property buffering, and scenic view preservation. There are two primary roadside views: those from the roadway and those toward the roadway. In addition, many environmental functions, such as noxious weed control, wetland and sensitive area preservation, and habitat preservation are readily perceived and evaluated through sight.</i>
<i>Auxiliary functions</i>	<i>Those functions that provide additional operational, environmental, and visual functions for a complete transportation system. Examples of auxiliary facilities are community enhancement areas, safety rest areas, roadside parks, viewpoints, agricultural uses, heritage markers, bicycle and pedestrian facilities, park and ride lots, quarries and pits.</i>

Table 3.1 Road side functions.(Source; WSDOT, 2014.)

3.1.1 NATURAL RESOURCE MANAGEMENT AND LANDSCAPING

“When a road side development is designed well, the road side and surrounding landscape becomes an important component of the road network.” (RTA, 2008, pg.4). It is very essential that a road way be integrated with its surrounding to create a pleasant scenic view and ecologically sound landscape for its sustainability. This can be materialized through soft landscape and hard landscape design using natural and man-made features. Soft landscaping is Turfing and Seeding and can further be divided into ground works such as excavation, drainage, irrigation, erosion control and earth work while hard landscaping is concreting, fencing, edging, masonry work, metal work, finishing, paving, structure and timber works respectively, (RTA, 2008)

3.1.2 SOILS IN THE URBAN ENVIRONMENT

Soil is the major component that controls the ecological quality of nature and urban environments. A road side development provides an opportunity for conservation or restoration of soils affected by major development projects such as highway construction.

Soils have always performed a wide range of useful functions. The range of these functions and impacts on the environment has changed considerably in the urban environment as land use is converted from rural to urban. Failure of the soil to function as expected can have a significant effect on the urban environment, resulting in serious impacts including damage to buildings and roads, land slip, poor water quality, soil contamination, dry land salinity and degraded ecosystems. Although generally associated with agriculture, horticulture and forestry, soil also underlies most of our cities and urban hinterlands. In the urban environment soils may vary in natural condition, be slightly disturbed or completely disturbed, as in the case of man-made landscapes. Whether in a natural or disturbed condition, soils vary widely in their property. Disturbed soils, as in the case of the study area where massive earth overhauling is underway, differ from soils in natural areas because their horizons have been mixed, destroyed or removed. The natural soil properties have changed. Sub soils are exposed and mixed with top soils and compaction may have occurred. Natural soils may have buried under fill; chemical and waste materials may have been added. All these activities can result in large changes in the physical, chemical and engineering properties of the soils at a site. The natural properties of the soils, or the changes to their properties, can determine whether the soils can carry out the engineering, environmental, hydrological, physical, chemical and biological functions required for the urban environment. The importance of the soil in sustaining day to day urban community activities such as creating ecologically integrated and sustainable corridors is often not appreciated. Overlooking its importance can have adverse consequences, (Hezelton, P. and Murphy, B.,2011)

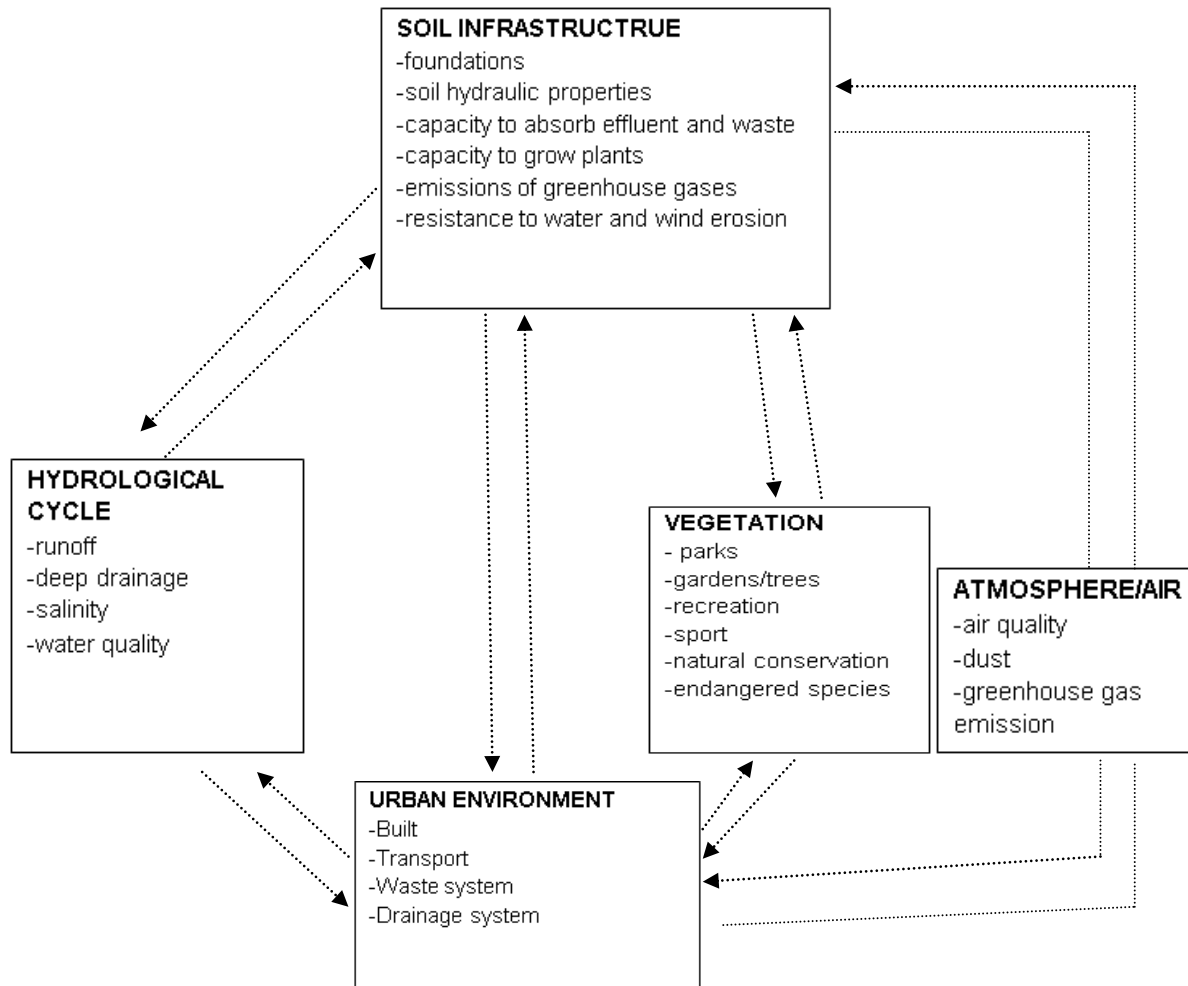


Figure 3.2: the interaction of soil with other aspects of urban environment, including the human and biophysical environment.

Source; Hezelton, P. and Murphy, B., 2011

Therefore, soil is the key component of the urban ecosystem and the natural infrastructure of urban land by which ecological, integrated and sustainable road side development is achieved, (Hezelton, P. and Murphy, B.,2011)

The importance of soil is underestimated in an urban or city environment. Soil lying beneath the feet of urban dwellers-it nourishes garden and park lands, support building foundations, underlies transport corridors and is often used as a sink for effluent and waste disposal. It is also a medium in which vegetation grows, often to

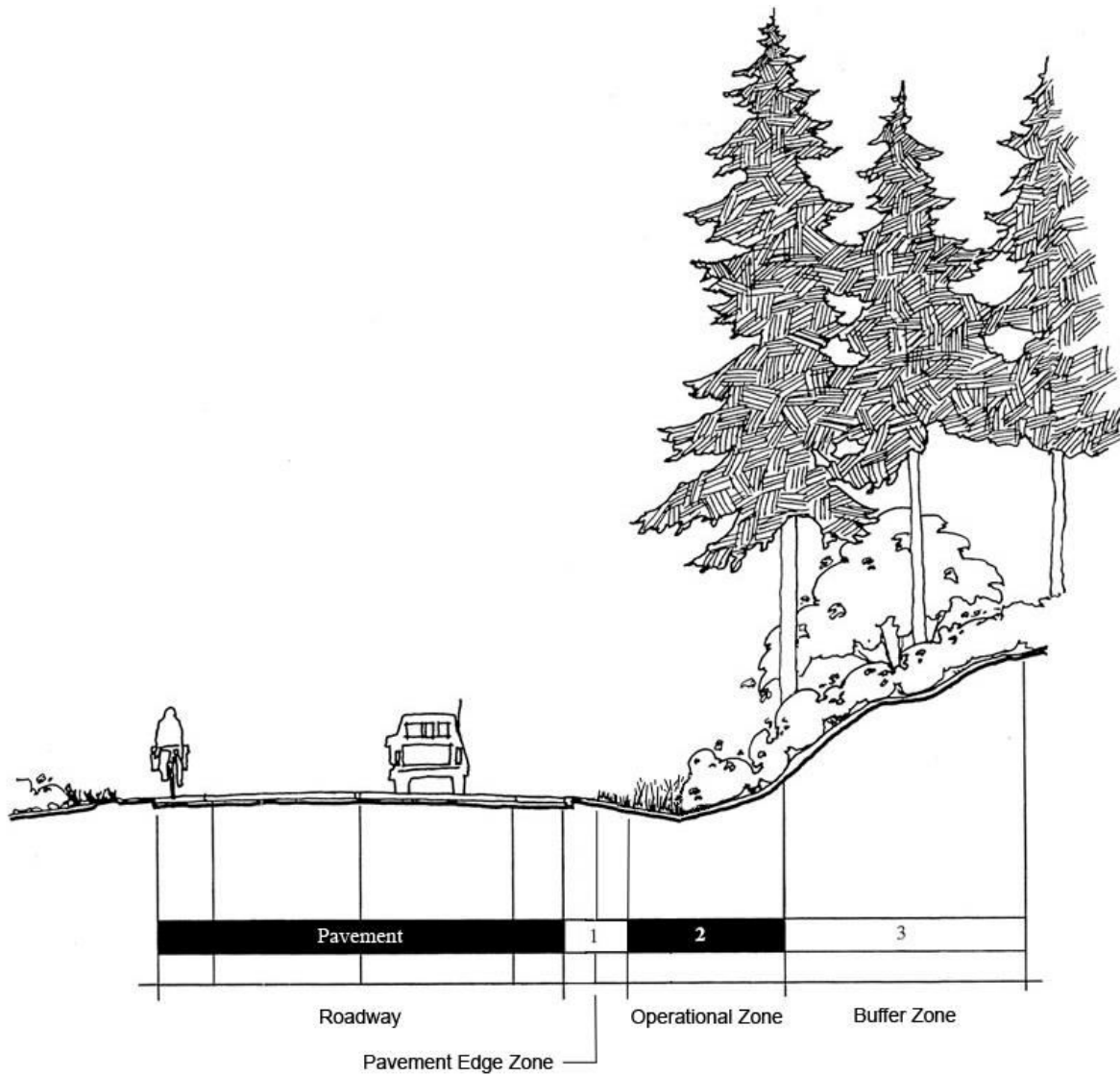
remediate sites which have been scarred by change in the landscape. Failure of the soil to function as expected can have a significant effect on the urban environment, resulting in serious impacts including damage to buildings and roads, land slip, poor water quality, soil contamination, dry land salinity and degraded ecosystems. To prevent degradation and loss of productive soil resources, and to achieve environmental quality and hazard protection in cities, professionals need to interact with all stakeholders and policy makers to ensure that the potential problems of working in urban soil can be assessed and managed sustainably, (Hezelton, P. and Murphy, B., 2011)

3.2. ENVIRONMENTAL FUNCTIONS OF ROAD SIDE DEVELOPMENT

Environmental functions include water quality preservation, protection and improvement; storm water detention and retention; wetland and sensitive area protection; noxious weed control; noise control; habitat protection; habitat connectivity; air quality improvement; and erosion control.

Environmental functions are inseparable from operational, visual and auxiliary functions. For example, a central median can provide visual screening from oncoming traffic, reduce headlight glare to improve safety, provide habitat for certain wildlife, and provide a location for storm water collection, (WSDOT,2014).

Environmental functionality of a developed road side is managed in three zones. Zone 1 is a vegetation free zone immediately adjacent to the road way, Zone 2 typically contains the clear zone, where designed clear zone may extend beyond the right of way line, and Zone 3 extends from Zone 2 to the right of way line, (WSDOT,2014,pg.110).



Pavement Edge Zone

Low Growing or Routinely Mowed Vegetation and/or Vegetation-Free Strip
 Maintained using mechanical and/or chemical methods for sight distance, stormwater drainage and filtration, noxious weed control, pavement preservation and roadside hardware maintenance.

Operational Zone

No Vegetation with Stem Diameter Greater than 4"
 Maintained using IVM techniques for sign visibility, sight distance, errant vehicle recovery and weed control.

Buffer Zone

Native or Naturally Occurring Vegetation
 Where adequate right of way exists, maintained using IVM techniques to encourage desirable, self-sustaining plant communities.

Figure 3.3; Road side management Zones
 Source: WSDOT, 2014

3.2.1 BENEFITS OF ENVIRONMENTAL FUNCTIONS OF ROAD SIDE DEVELOPMENT

The soil and Vegetation are the key components within the biosphere and lithosphere where the environmental functions are built upon. For example vegetation has many functions and adds significant values to our environment.” (State of Oregon, 2006, pg.8).Hence, it is an excellent choice for road side development to bring forth positive behavioral influences and environmental effects to road side and immediate vicinity users.

3.2.1.1 POSITIVE BEHAVIOURAL INFLUNCES

A variety of behavioral responses are attributed to vegetation along road ways.

- Memory impression or sense of place- perceptual or cognitive factors influences the memories or impressions of an area, helping to provide a sense of place. it is the road side and a view from the road side that the driver or visitor remembers long after having driven along the road, (State of Oregon,2006). It is one of the key elements that contribute to the character of an area – the combination of landscape and built form that helps provide a unique sense of place and of value to the community, (RTA,2008).
- Reinforcing community character or corridor continuity – road sides are more than a buffer for a community; they are often a transition into a community. Drivers associate and derive impressions about communities by what they see along the road side. The road side can be the community amenity. The preservation of visual quality strongly supports the economic interests of the state through the tourism industry, (State of Oregon,2006).
- Scenic preservation-the presence of natural features and the perception of a clean natural environment have often been linked with positive visual preference. Among scenic road way users natural features (lakes, rivers, mountains, hills, natural vegetation, and long distance views) are most highly valued. The public values visual features that fit the locality and contribute to a sense of place(State of Oregon,2006) and so planting vegetation helps to integrate or fit the road, including its road side and immediate vicinity, into its setting and unify the road corridor environment, (RTA,2008).
- Driver guidance and navigation – road side features can create patterns that provide the driver with clues to what lays ahead. An effective highway design is based on predictability and coherence in the visual environment (corridor continuity). It anticipates driver’s expectations and surprise factors, and gives the driver sufficient visual information to accurately predict upcoming road way conditions. This information forewarns drivers and prevents accidents. The sequence of visual events leading to an appropriate decision must be organized to meet this objective. Land use, site distance, terrain, corridor

continuity, screening destructions, and reinforcing visual features give the driver clues about the road ahead. Highway alignment, road way geometrics, vegetation and structures all contribute to driver guidance. And thus integrates and fits the road into its setting, (State of Oregon,2006).

- Traffic calming – applying softening effects of pedestrian amenities and landscaping. The motorist’s natural speeds are often slowed due to the perception of a changing road culture, (State of Oregon,2006).Planting should be an integral part of noise barrier design. Plants absorb and scatter sound to a small degree and the effectiveness of plants as noise reducers is limited because of considerable width height and density required. The principle noise reduction effect of planting is psychological. When it is not possible to use structural barriers or other means of attenuation, planting may reduce human annoyance and awareness of the problem by screening the noise source from view. Evergreens are best for this purpose, but they may be used in combination with dense deciduous plants. Planting should be an integral part of noise barrier design. Plants usually soften their effect and reduce the perceived massiveness of the barriers. In addition to trees and shrubs, vines are very effective for this purpose, (RTA,2008).
- Vegetation is a valuable ecological asset in an area, especially when existing habitats and ecological corridors need to be augmented,(RTA,2006).
- It provides shade for pedestrian and building and a setting to take a break from driving in rest areas along the road network.(RTA,2006).
- Directed attention fatigues –people use directed attention to work in distracting surroundings and make decisions in complex situations, such as driving in heavily surrounding roads. The visual environment can aggravate or alleviate directed attention fatigue. Extended unrelieved periods of directed attention can diminish the capacity to analyze, plan and make decisions resulting in irritability and taking unnecessary risk. Visual access to natural environments is one of the key elements in counteracting directed attention fatigue through restorative experience. Careful planning and design of corridor views for scenic vistas and aesthetically pleasing road side treatment can be important in improving road way safety, (State of Oregon,2006).



Figure 3.4a



Figure 3.4b

Figure3.4a: shows a typical example where the landscape of the road side contributes to the quality of Journey and the quality of the road. (Source; RTA, 2008)

Figure3.4b: Uses of distinctive trees can provide subtle warnings of urban areas ahead and differentiate between settlement and rural areas. (Source; RTA, 2008)

3.2.1.2 ENVIRONMENTAL EFFECTS

Vegetation is a valuable environmental tool to design ecologically integrated road side and immediate vicinity development to create environmental effects.

- It can contribute to a safer road, for example by screening sun light and a head light glare, slowing errant vehicles, and helping create an intuitive self-explaining driving experience, (RTA,2008).
- It is valuable in terms of impact mitigation. It screens undesirable views of road and traffic, helps filter air and water pollutants, suppresses weed growth as vegetation and vegetation of sites helps to control weed, helps reconnect habitat, and can help recover threatened species. It also minimizes the carbon footprints of road works by capturing polluting carbon particles and reducing carbon dioxide and producing oxygen-for at least the life time of the landscape and so improves the air quality, (RTA,2008).
- Energy conservation – trees reduce solar heat gain and provide shade. Trees help moderate the 'heat island' effect and greatly increase human comfort indoor and outdoor. On hot days, trees pump hundreds of gallons of water through their foliage. This water evaporates keeping the tree and its

immediate surrounding cool. Trees shade soil, pavement, building and other surfaces that would absorb solar energy and then radiate the heat back to the surrounding,(State of Oregon,2006).

- Stabilizing slopes and minimizing erosion, (Refer Section3.1).

3.3 SOIL AND VEGETATION CONTRIBUTION TO SUSTAINABLE ROADSIDE DEVELOPMENT

“Vegetation provide shading, evaporative cooling, rainwater interception, storage and infiltration functions that are among the major Environmental Functions of Road side development. Plant growth nutrition and water transfer are closely linked to soil properties. Soils in landscape projects of urban environments often have limitation for the growth of trees. Heat islands associated with the construction of extensive pavements can cause soil temperature to increases. Rain water runoffs are often piped to storm water drains due to very little or no vegetation cover and so water supply to wet the soil and create conducive moisture for vegetation growth is limited. Furthermore, microbial activities within the soil and its associated nutrient cycling can be inhibited with the introduction of urban entities like major corridors and pavements. One of the inherent problems with the use of soils in urban areas is that the properties of the soils for engineering purposes are diametrically opposed to those required to grow plant. Hence when the construction or development phase is completed, the soil properties may not be favorable to plant growth unless provision has been to maintain or restore the soils condition to make it suitable to plant growth.”(Hezelton, P. and Murphy, B.,pg.108)

Environmental functions of road side development is greatly enhanced by tree planting which may need to extend beyond right of ways for the sustainability of a road way itself which eliminates or reduces impacts of moderate to severe soil erosions threatening functionality and stability.

3.3.1 MEASURES OF EROSION CONTROL AND SLOPE STABILIZATION

Bio engineering techniques such as using live woody plant with combined inert structure as a reinforcement and barrier to soil movement, vitiver grass for erosion control, river bank stabilization using reeds and geo textile are among the major practices of physical/ structural and biological measures for sustainable road side and immediate vicinity development.

Soil and water conservation technologies comprised of vegetative, structural, agronomic and management measures are the best tools to stabilize soil and reduce erosion. Vegetative measures are planting grass strips,

hedge barriers, and wind breakers or shelter belts etc. Structural measures are building terraces, banks, check dam etc. Agronomic measures are mixed cropping, contour cultivation, mulching and so on. Management measures include land use change, area closure, rational grazing etc, (Gerhard A.,2013).



Figure 3.5



Figure 3.6

Figure 3.5: Typical examples showing-highly erodible tropical soil where newly cut batter is eroded during the wet season, (source; Nevil B and Paul T, 2000)

Figure 3.6. Erosion and sedimentation problem on unprotected batters of culvert inlet and outlet, (source; Nevil B and Paul T, 2000)



Figure3.7



Figure 3.8

The above figures, figure 3.7 and 3.8 show how a fill batter is highly erodible by intensive storm if left unplanted or without vegetation cover.

(Source; Navil B and Paul T, 2000)



Figure 3.9.a.



Figure 3.9.b.

Figure 3.9.a. Example of a fill batter stabilization successfully done by planting vetiver grass. (Source; Navil B and Paul T, 2000)

Figure 3.9.b. shows that vetiver roots are used to stabilize built terraces. (Source; Prof. Gerhard A.2013)



Figure 3.10 .a.



Figure3.10.b.

The above figure 3.10.a. illustrates an expensive concrete shoulder dyke while figure3.10.b exemplifies a vetiver planted along the road dyke. (Source; Nevil B and Paul T,2000)

Consequently, Nevil B and Paul T have explained that Vetiver hedges planted on edge of road shoulder provide similar and yet cheaper and more effective protection to the shoulder and culvert outlet of a road than built expensive concrete shoulder dyke. In addition vetiver planted outlet is used to drain off water accumulated along shoulder dyke. It also collect and divert surface runoff to concrete Shute. Furthermore, on wide table drain, short rows of vetiver grass planted on contour line spread water flow as well as reduce flow velocity and trapped sediment.



Figure 3.11.a.



Figure 3.11.b.

The above figures, figure 3.11.a and figure 3.11.b., shows a road side gully erosion which can eventually undermine stability of road pavement if left unrepaired and may cause the road to collapse, (Source; Nevil B and Paul T, 2000)



Figure 3.12.a.



Figure 3.12.b.

The above figures, figure 3.12.a and figure 3.12.b. demonstrate construction of gabion check dams, after reshaping gully wall and building retaining walls, is the initial stage to retain soil in its place. It is then followed by planting vegetation to anchor the soil further,(source; Gerhard A.,2013)

Vegetation and street trees improve the water quality of our rural and urban environment as they reduce storm water runoffs and as a result;

- Improve water quality of rivers and streams by capturing rainfall and reducing erosion and runoff(RTA,2008)
- Provide shade and cooling of streams, essential to fish and other aquatic life, (RTA,2008)
- Prevent millions of gallons of rain water from entering the sewage treatment plant, (State of Oregon, 2006).

Moreover, prevention of millions of gallons of polluted runoffs from entering to streams and rivers is possible by constructing bio filtration swales where plants are used in channels to capture biologically degrading

pollutants carried by storm water runoffs. Bio filtration swales also reduce the velocity and volume of storm water runoffs and can be provided by Bio filtration strips as well. Bio filtration strips, also known as vegetated buffer strips, are vegetated sections of land over which storm water flows as sheet flow, whereas Bio- filtration swales are vegetated channels that receive and direct the concentrated flow of storm water. Acceptable vegetation for Bio filtration includes grasses, forbs and ground cover, (RTA, 2008)

3.4 CONCEPTUAL FRAME WORK of LEGISLATIONS AND DIRECTIVES FOR ENVIRONMENTAL FUNCTION DEVELOPMENT OF ROAD SIDE

Sustainable road side is planned and designed with intent of integrating successful, operational, auxiliary, visual and environmental functions. Sensitive or critical areas within a landscape, which is subjected to natural hazards and supports unique, fragile or valuable natural resource within the scope of municipal development needs to be protected by legislations or official declarations,(WSDOT,2014).

To define and designate critical or sensitive areas according to conventions for nature conservation and landscape management is mandatory for sustainable infrastructure development. We need for our generation and next to live in an ecologically intact environment and support sustainable infrastructure development. Thus special care must be taken in all steps of road side development to ensure appropriate stewardship of wetlands and their associated buffers which identify wetland boundaries, categories and types, assessment of functions and evaluations of impacts requiring the expertise of trained professional. Moreover, all construction activities have the potential to cause soil erosion. Therefore, erosion prevention and sediment control needs to be components of any project that disturb vegetation and soil horizons. Implementing plans- followed by design, construction and maintenance, for erosion preventions will reduce both the need for costly sediment control and the risk for environmental damage, (WSDOT, 2014)

A local landscape plan can be an instrument to exercising environmental precautions. It creates the planning prerequisites that will enable us as well as the future generations to live in an ecologically intact environment and supports sustainable municipal development,(BFN,2002)

Substantive elements of a local landscape plan based on nature conservation and landscape management enforced by Acts and Legislation may comprise the following;

- ✓ Field inventory of the existing and anticipated status and nature of an environmental element

- ✓ Developmental objectives in line with nature conservation and landscape management for the specific are in question.
- ✓ Ecological networks while eliminating or reducing adverse effects upon nature and landscape by fostering the livelihood of fauna and flora.
- ✓ Taking special care of areas, which by virtue of status, location or natural opportunity for development are particularly well suited to future nature conservation and landscape management measures or to the development of habitat network system.
- ✓ Requirements and measures to protect, improve, regenerate soils, water bodies, air and climate.
- ✓ A target to conserve and develop the diversity, unique character and beauty of nature and landscapes, as a place for human enjoyment and recreation.

A local landscape plan, incorporated within road side development practices in Ethiopia, may support impact mitigation to prevent deterioration of potential and functional capacity of the natural environment and landscape. These are ecological services of flora and fauna, their habitats as well as the soil, air, water and climate including unique character and beauty of landscapes' scenic qualities.

“Impact Mitigation Procedures establish prevention and compensation requirements which must be taken into consideration in local development planning”(BFN,2002,PG.8).

3.5. SYNOPSIS OF ROAD SIDE (RIBBON DEVELOPMENT) IN ETHIOPIA

“MEF, Ministry of Environment and Forest which is used to be known as Environment Protection Authority (EPA), has delegated five sectors distinctively to check and approve Environmental Impact Assessment (EIA) requirements and permits to give certificate of license to municipal or civic developments. As a result, certificate or environmental clearances of road projects are issued by the ministry of transport. MEF as an over seer of all the delegated ministries, has appointed licensed consultants for EIA management of the Express way while being a Trans boundary development in its nature, it required Federal government interference” said Ato Yohannes Amaha, Environmental licensing expert at MEF concerning the development of the Express way.

Meanwhile Ato Kefargachew Kassahun, team leader of the Environmental and social management team at Ethiopian Road Authority (ERA), has said that ribbon development is always expensive since it requires tradeoffs with different clients regarding demarcations of boundaries and resettlements. For such reasons it has never been a priority in ERCC's agenda. The trend is used to be traditional type where utilities and drainages are the main concern for a road side development.

However, since recently according to Ato Kefargachew Kassahun, ERA is setting priority trends for public development which is more a nontraditional road side development approach tending to consider diverse range of context sensitive environmental features ,natural resources and landscape management.. Accordingly, his team mobilizes the supervisor in ERA which is the Climate Resilient Green Economy (CRGE) unit to supervise EIA and impact mitigation procedure (IMP) implementations of ribbon developments. He raised the case of Bedele – Metu road construction project where his team prepared a terms of reference for a lump sum of 5 million birr for aforestation financed by African Development Bank (ADB). Ato Kefargahew said that the project which is supposed to be assisted by agricultural and environmental development sectors, failed due to the lack of assistance from public offices such as the regional administration and Bureau of Agriculture, China Communication and Construction Corporation (CCCC) have outsourced the cut and fill slope stabilization for a contractor which has now stopped the work due to cost implications.” He added that CCCC is liable for maintenance of the Express way within 10 years of project completion.

The Environment and Social management team at ERA develops the Environmental and Social Management Plan (ESMP) as a client for all road construction projects which are incorporated within a tender as part of the bid document in line with the feasibility study, route selection and EIA details prepared by the design consultant. A standard for the length of right of way is set within where the ribbon development is expected to be constructed. In the case of the Express way ribbon development is far from completion. Sustainability of the Express way, with a **25 ±5** years of expected service, is thus highly dependent upon the implementation of its road side development and landscape management within its right of ways and beyond for peculiar, critical and sensitive issues of its landscape. Finally, the team leader has mentioned that a 90 meters of right -of-way is requested by donors for the coming MODJO-AWASSA Express way construction by donors where ribbon development of such extent and quality is to be the first of its kind in Ethiopia..

However, the Express way has a commendable functionality regarding Operational functions of road side development while Auxiliary and Visual road side developments are still half way to be achieved because of their integration with the Environmental function. This is due to the fact that many environmental functions, such as noxious weed control, wetland and sensitive area preservation, and habitat preservation are readily perceived and evaluated through sight, enhancing the visual functionality. Meanwhile, an Auxiliary function such as road side parks, ride lots, pedestrian facilities and agricultural land uses promotes and increases environmental function. Ribbon development for the express way is limited to the traditional type and do not address context sensitive and critical issues of its landscape.

Finally, from the exclusive interviews with the designated professionals from each sector offices and a look into the actual scenario of the Express way construction, it is possible that there is a lack of **common** understanding enforced by official declaration between all stakeholders and policy makers with the necessary law enforcements regarding the definition and extent of road side development and landscape management which must consider a nontraditional development approach and raise context sensitive and critical issues of soil erosion within its landscape.

4. MODELLING SOIL EROSION BY WATER

In the research, the spatial distribution of soil erosion, the prediction of erosion patterns and identification of locations of high risk areas for erosion within the study area have been assessed in depth using RUSLE model of soil loss with the help of Arc GIS 10.2, AIRDASS and Global mapper software. This approach is chosen because it addresses the fact that soil erosion is a function of spatial variation and interaction of different natural and anthropogenic factors such as Topography (elevation and slope), Land use land cover, soil type, drainage pattern and rainfall. These factors are taken as model parameters to define the existing natural environment and landscape of the study area.

4.1 DATA ANALYSIS AND DERIVATION OF RUSLE MODEL

4.1.1 RAINFALL EROSIIVE FACTOR (R_factor)

Erosion due to rainfall depends on amount, intensity and distributions it. The soil loss is closely related to rainfall partly due to its detaching power by raindrop striking to the soil surface and partly through the contribution of rain to runoff. The value of R for Ethiopian condition is estimated using the following equation.

- $R = -8.12 + 0.562 \times P$ where, R = Rainfall erosive factor, P = mean annual rainfall (mm/yr), (Amsalu ,T. and Megnaw A.,2014)

To compute R factor, mean annual rainfall of 10 years were collected from different stations at Addis Ababa, Debreziet, Modjo and Nazareth (Table 4.1) calculated R factor is then converted to Raster surface using IDW (Inverse Distance Weighted) by interpolation method using Arc GIS software to generate R_FACTOR MAP.

Gh Id	STATION	LOCATION		ELEVATION	MEAN ANNUAL RAINFALL	R-FACTOR
		LAT.	LONG.			
SHADD121	ADDIS ABAB	90108	384451	2386	1162.7	645.3
SHDEBR42	DEBREZIET	84400	385700	1900	748.8	412.7
SHMOJO13	MODJO	83619	390629	1763	864.5	477.7
SHNAZ11	NAZARET	83300	391700	1622	780.6	430.6

Table 4.1: Mean annual rainfall in mm/yr over ten years at each 4 stations near to the study area for RUSLE assessment.

Source: National Metrological agency.

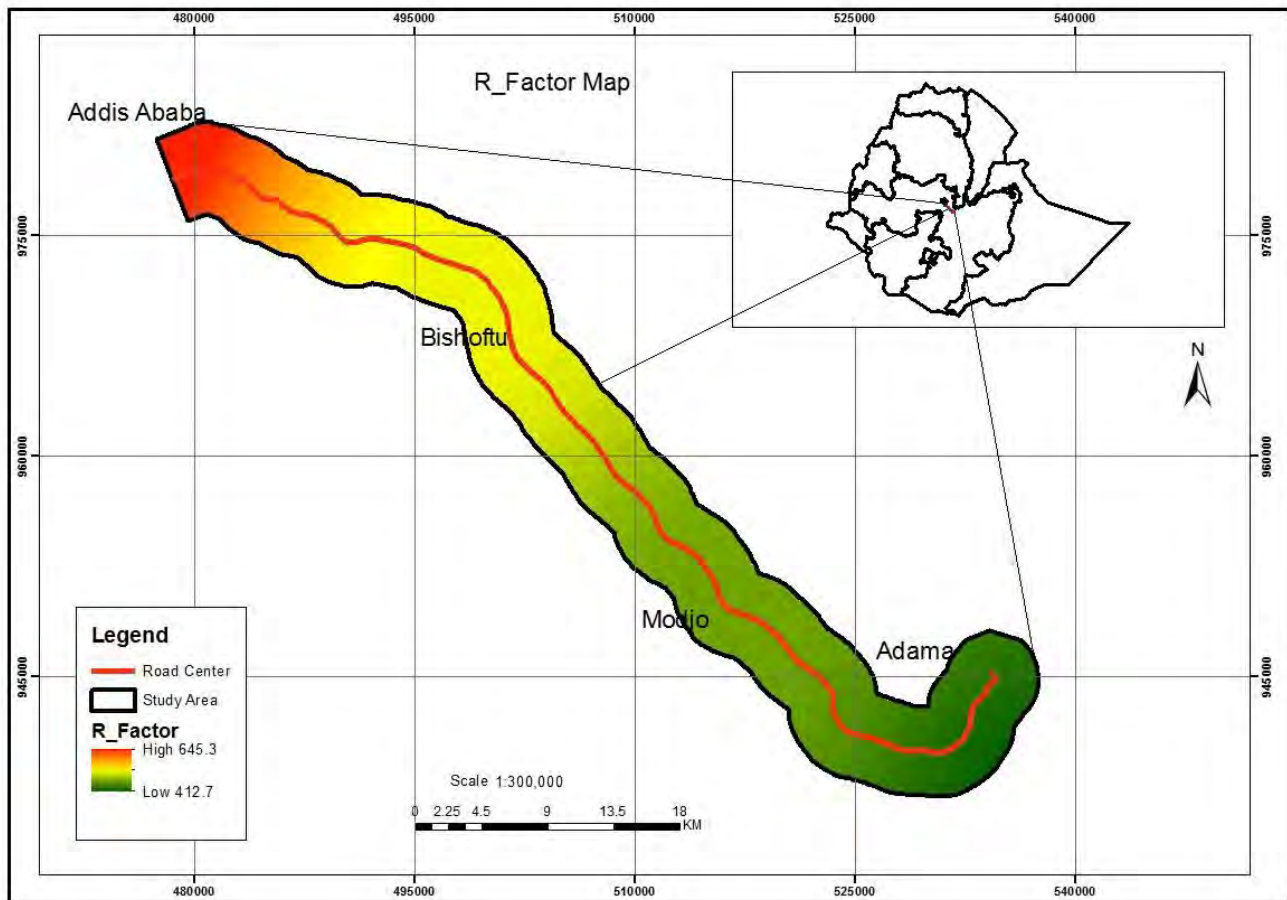


Figure 4.1: Rainfall erosive factor (R_factor)

4.1.2 SOIL ERODABILITY FACTOR (K-FACTOR)

Soil erosive factor (K-factor) is defined as mean annual rainfall soil loss per unit of R for a standard condition bare soil, recently tilled up-and-down with slope with no conservation practices and on a slope of 5° and 22 length .Main determinants of soil erosive nature are soil structural stability and the soils ability to absorb rainfall. These properties in turn depends on a number of characteristics of the soil, such as texture, structure, organic matter content, soil depth and other physical and chemical properties of the soil. The value of K was given based on soil colors in RUSLE for Ethiopian condition shown on the table below.

For the analysis of K factor, FAO standard classification of soil types within the study area was used from where the soil types, **Chromic-Luvisols, Eutric-Vertisols, Haplic-Phaeozems, Mollic- Andosols, Vertic -Cambisols,** were identified, **(Refer figure 4.2 on the types of soil classes of the study area according to FAO).**

After changing the vector format in to grid, the grid dataset was reclassified based on K-values given by Table 4.3 and Figure 4.2, (Amsalu ,T. and Megnaw ,A.,2014)

SOIL COLOR	BLACK	BROWN	RED	YELLOW
K-factor	0.15	0.2	0.25	0.3

Table 4.2: Soil color and values to estimate its erosive nature accordingly

Source: Hurni,1985.

SOIL TYPE	COLOUR	K-FACTOR
Chromic Luvisols	Dark brown to dusky red	.0.2
Eutric Vertisols	Black	0.15
Haplic Phaeozomes	yellow	0.3
Mollic Andisols	Red	0.25
Vertic cambisols	Red	0.25

Table 4.3: soil color and its value to estimate erosive soil nature for RUSLE assessment.

To derive the K factor, field inventory was conducted and observation was used to decide on the color

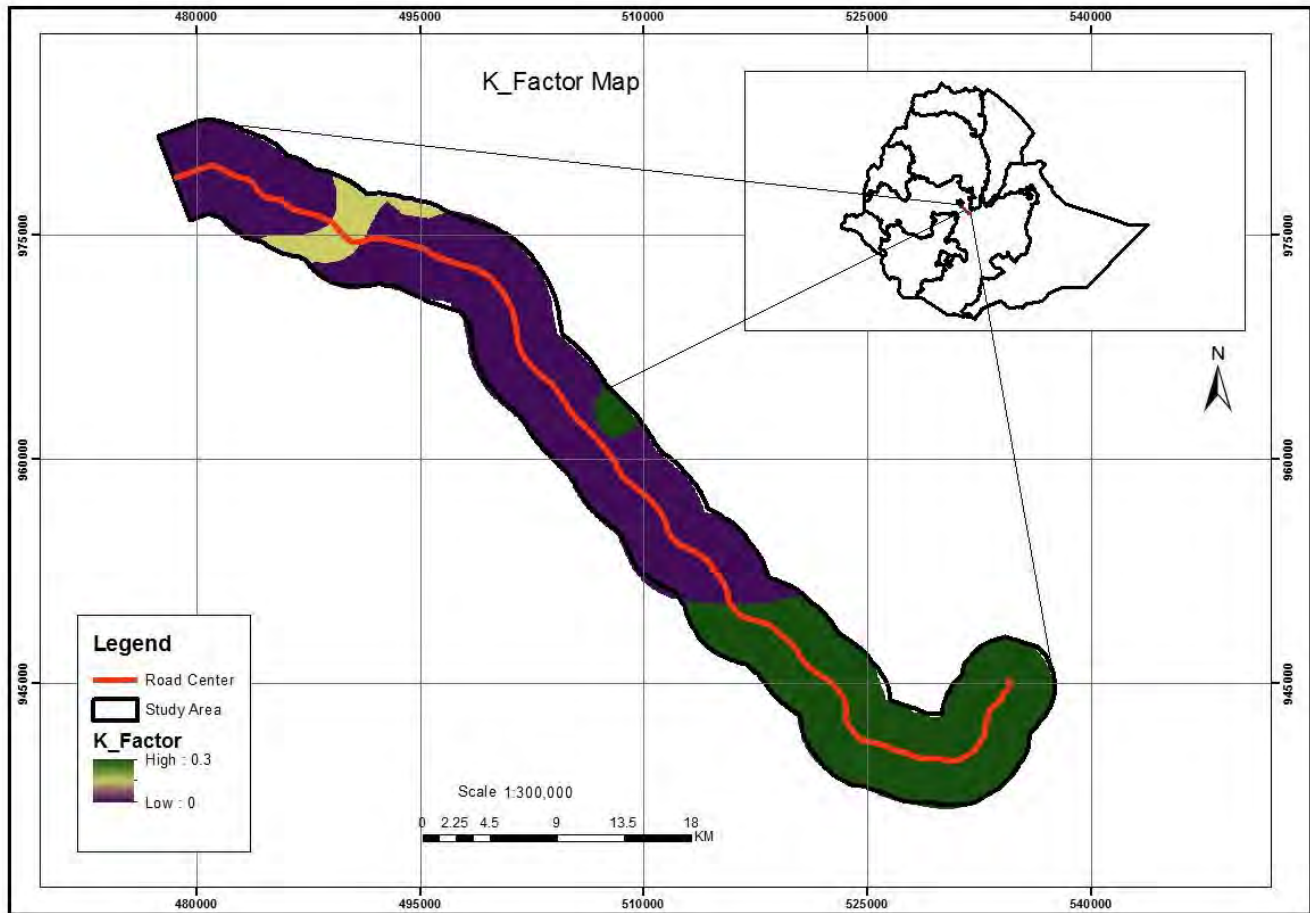


Figure 4.2: Soil erosive nature (K_ factor) map

4.1.3 TOPOGRAPHIC FACTOR (LS_ factor)

The slope length and slope steepness factors are commonly combined in a single index as LS and referred to as the topographic factor. Slope length is defined as the distance from the point of origin of overland flow to the point where either the slope gradient decreases enough that deposition begins or the runoff water enters a well-defined channel that may be part of a drainage network.

Slope steepness has been considered as one of the most model parameters in RUSLE analysis due to the fact that the steeper the slope of a field, the more it is pushed down hill, the faster the water runs and the greater will be the amount of soil loss from erosion by water. Soil erosion by water also increases as the slope length increases due to the greater accumulation of runoff.

The modified equation for computing the topographic factor (LS factor) in GIS environment is employed is as follows:

$LS = \{(\text{Flow Accumulation} \times \text{cell size}) / 22.1\}^{0.4} \times \{0.06S + 0.045S + 0.0065S^2\}$ Where flow accumulation is the number of cells contributing to flow in to a given cell and derived from the DEM after conducting **fill**, **flow direction** and **flow accumulation** processes in Arc GIS. Cell size is the size of the cells being used in the grid based representation of the landscape.

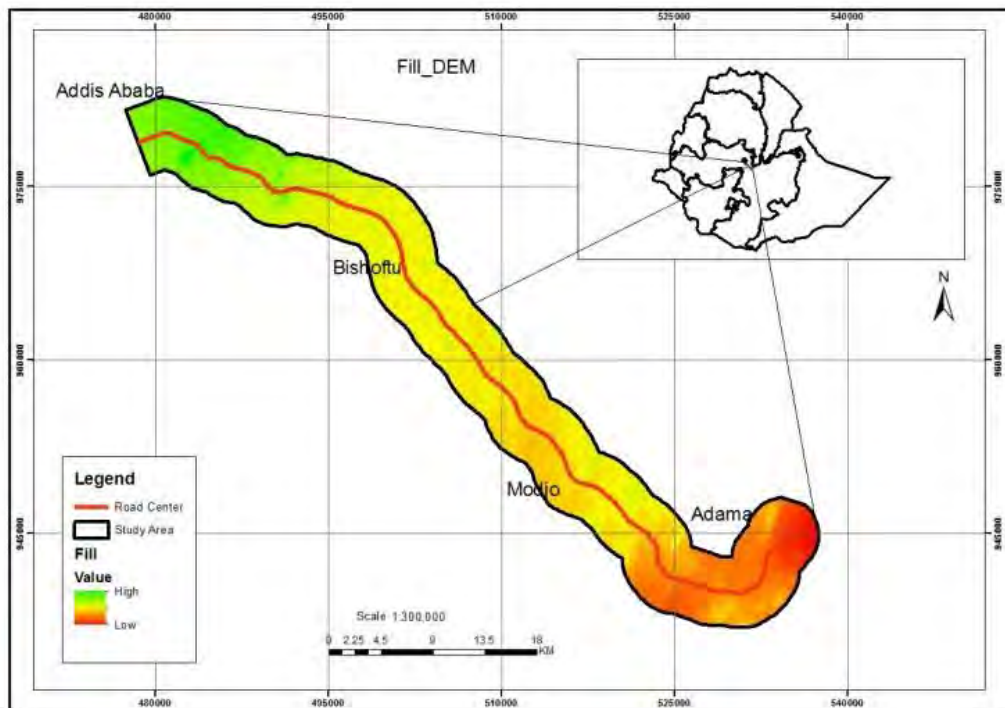


Figure 4.3a.Fill generated from DEM.

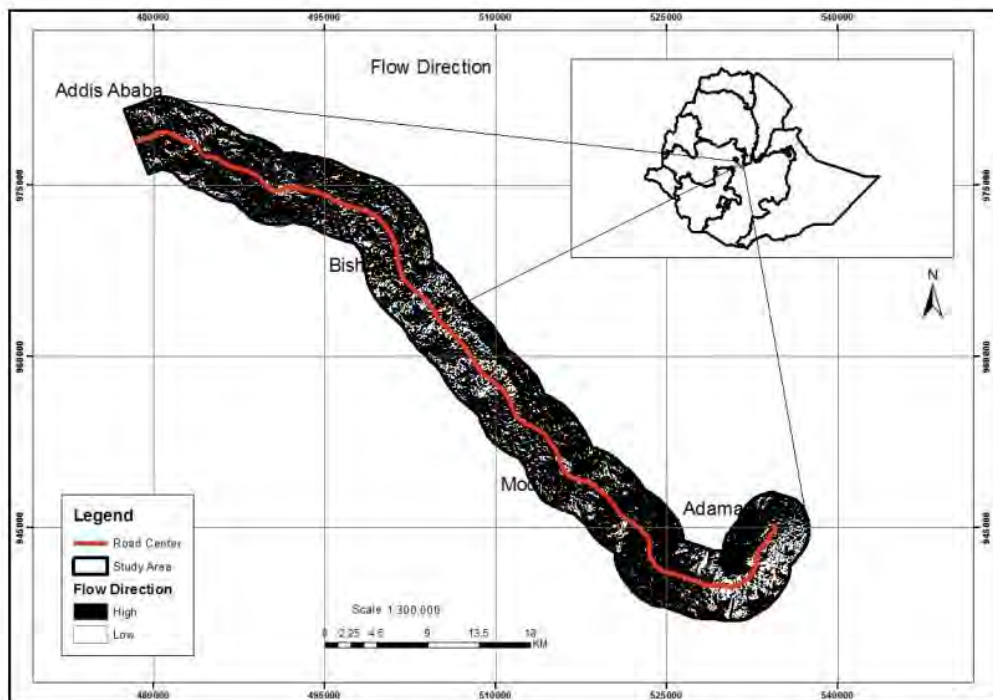


Figure 4.3b. Flow Direction derived from Fill

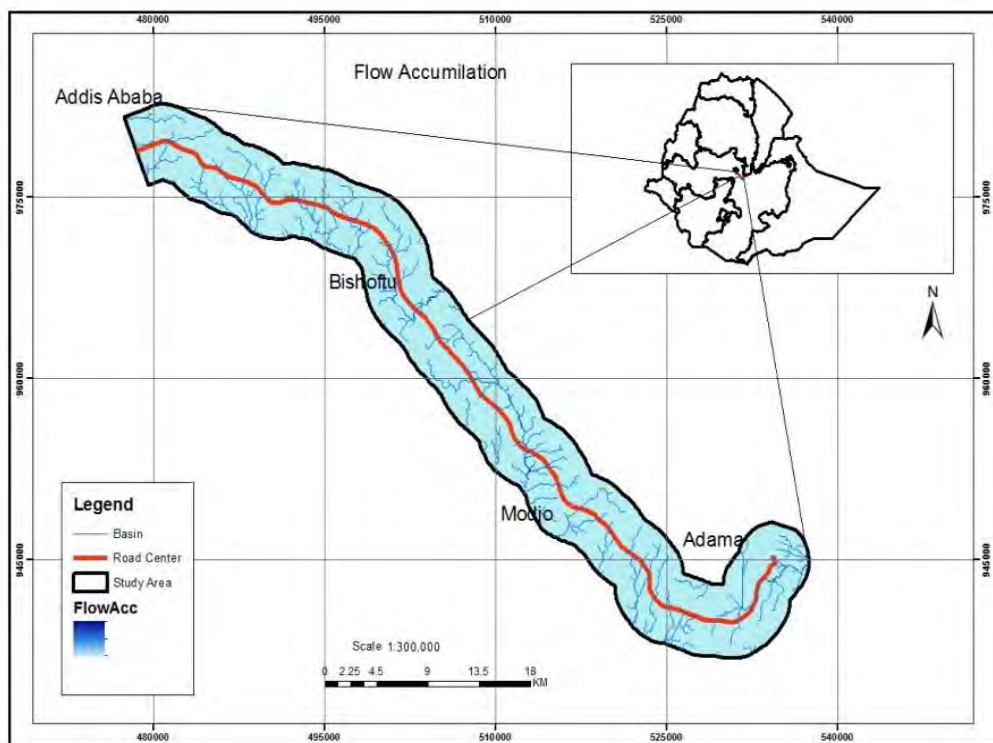


Figure 4.3c. Flow Accumulation derived from Flow direction

Finally, the LS factor map was derived using the above formula in Arc GIS spatial analysis raster calculator function, (Amsalu ,T. and Megnaw ,A.,2014).

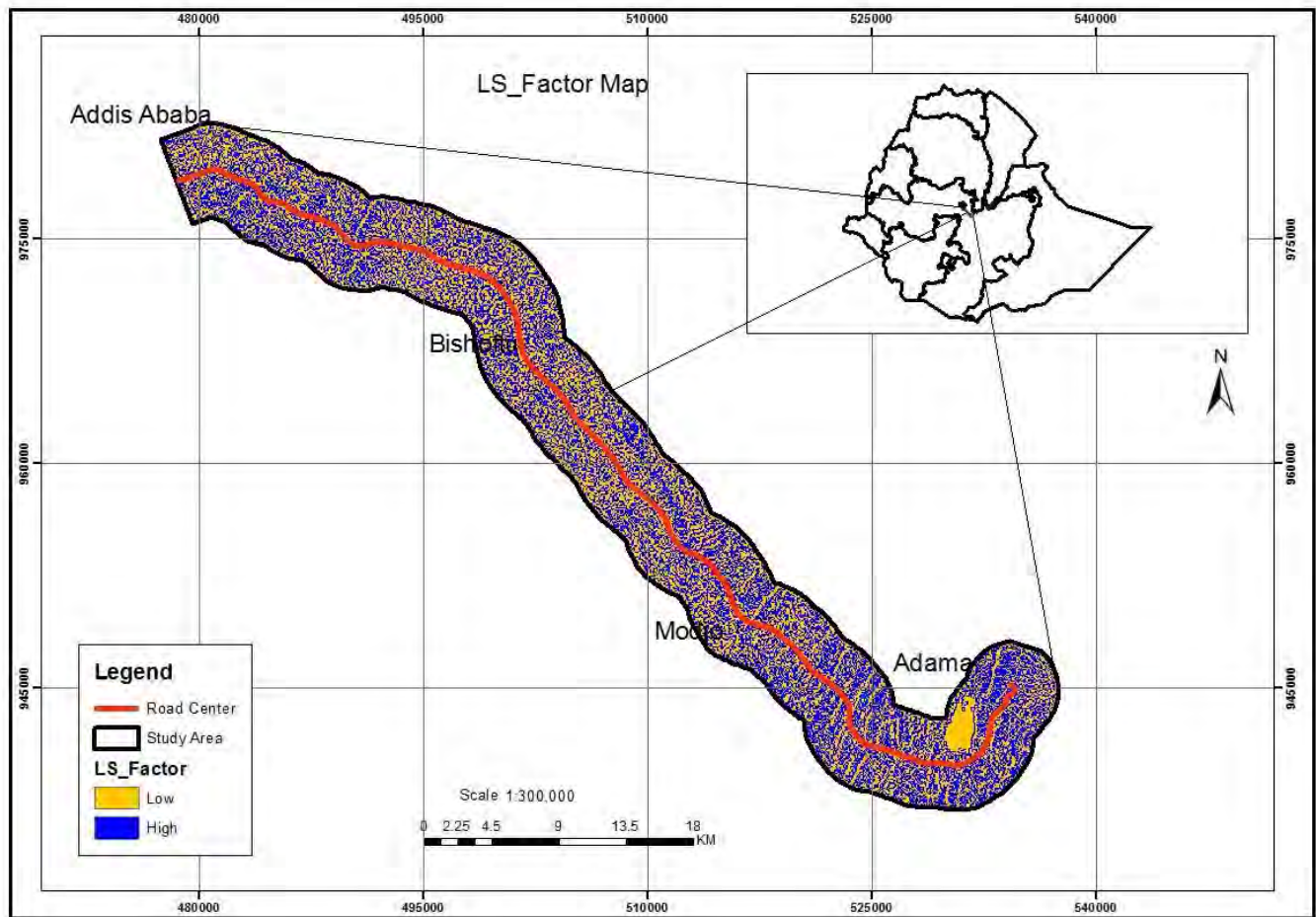


Figure 4.4: Topographic factor (LS_factor) map.

4.1.4. COVER MANAGEMENT FACTOR (C_Value)

The cover management factor represents the ratio of soil loss under a given cover to that of the bare soil. Land cover has a profound impact on erosion and deposition. Surface cover, such as vegetation or plant residue may intercept and reduce erosion due to raindrops, increase infiltration, slow down runoff. The land use/land cover map was used for the estimation of C-value. The raster land use/land cover map was converted to a vector format and a corresponding C-value was assigned to each land use classes based on cover values proposed by Hurni and RPC

Morgan. Finally, using reclassification and vector to raster conversion the land use/ land cover map was converted to C factor map, (Hurni,1985 and RPC Morgan,1995)

LAND USE LAND COVER TYPE	AVERAGE ANNUAL C_ Value
settlement	0.99
Wood land	0.01
Water body	0
agriculture /crop land	0.15
Bare land	1

Table 4.4: Land use land cover type and corresponding C_ values for RUSLE assessment

Source; Hurni 1985 and RPC Morgan 1995.

4.1.5. CONSERVATION PRACTICE FACTOR (P_ Factor)

Conservation practice and land management directly affects the overall soil erosion problem and solutions on a farm. In RUSLE, P factor is the ratio of soil loss with a specific conservation practice to the corresponding loss with up and down slope cultivation, which has a value of one. The P-value ranges from 0 - 1 depending on the soil management activities employed in the specific plot of land. P-factor is calculated for agricultural land only and for all other land use is assumed as 1, because there is no any control practice measures .To derive on the P_ value, field inventory taken and observation is used,(Tadesse A and Abebe M.,2014).

After assessing the conservation practice and their respective values, P factor map was developed in Arc GIS using land use/land cover map of the study area.

No-erosion control practice (in the case of bare lands and all land use types)	1
Agricultural or crop land	0.5-0.9

Table 4.5: Land use land cover type and corresponding P_ value for RUSLE assessment

Source: Amsalu ,T. and Megnaw,A.,2014.

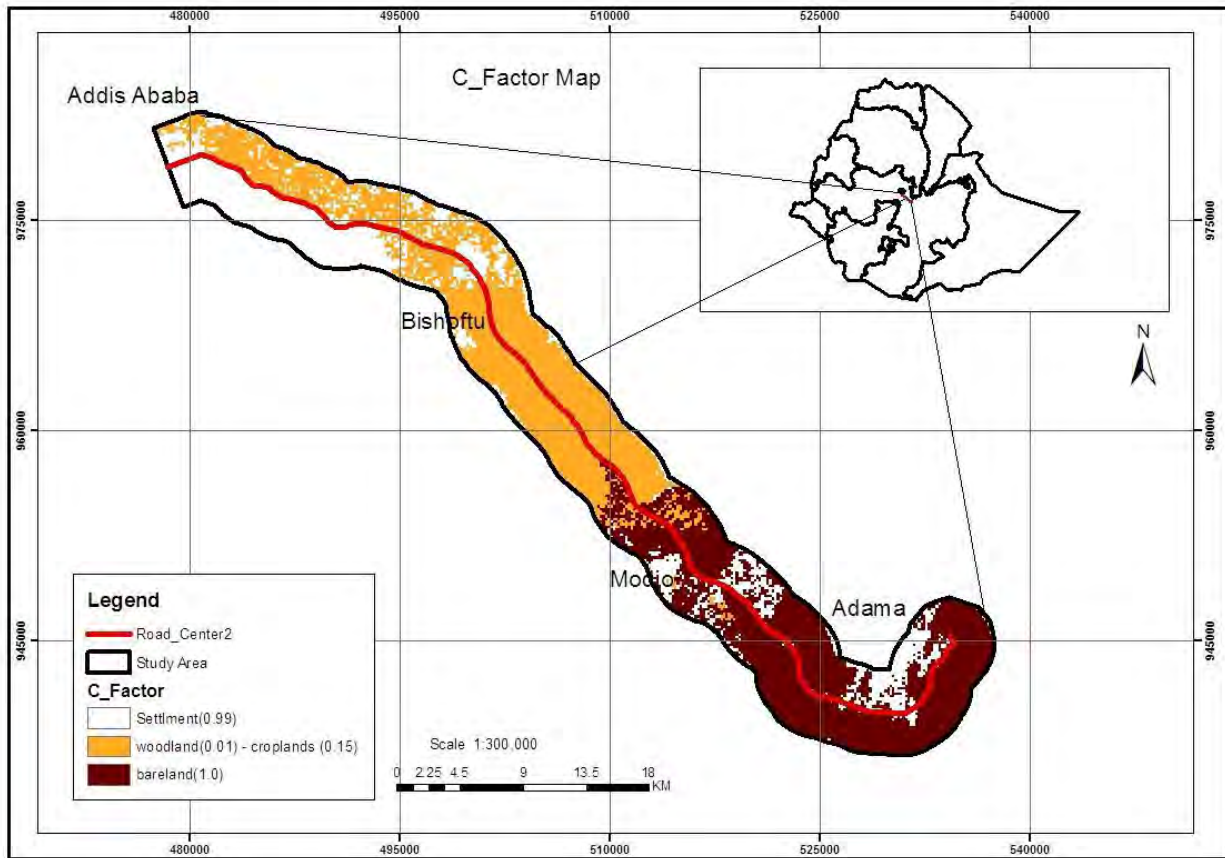


Figure 4.4: Cover management (C_factor) map

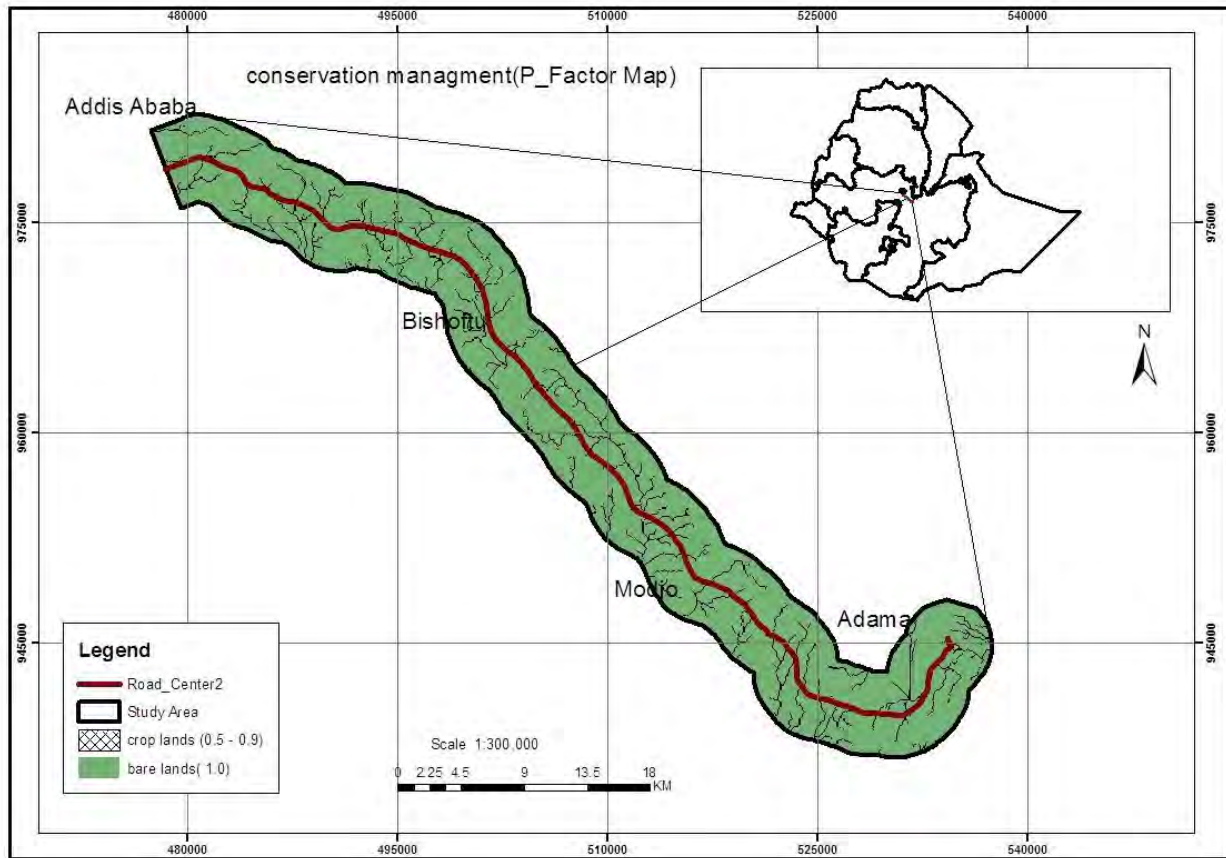


Figure 4.5: Conservation management practices (P_ factor) map.

5. RESULT

5.1 EROSION VULNERABILITY DISTRIBUTION

Spatial pattern and extent of vulnerability for soil erosion within the study area is ruled out using raster calculation of RUSLE model parameters in Arc GIS 10.2 which is a conceptual model showing empirical relationship between the models resulting in to two qualitative statistical categories. This conceptual model was illustrative of the physical processes of erosion inside the study area where the map algebra multiplies each factor parameters and displays pattern and extent of soil erosion.

$$E = R.K.L.S.C.P$$

Where E= Mean annual soil loss, 'R' is the rainfall erosivity factor, 'K' is the soil erodibility factor, 'L' is the slope length factor, 'S' is the steepness factor, 'C' is the crop management factor and 'P' is the erosion control practice factor, (Amsalu, T.. and Megnaw, A.,2014. And Morgan, 1995)

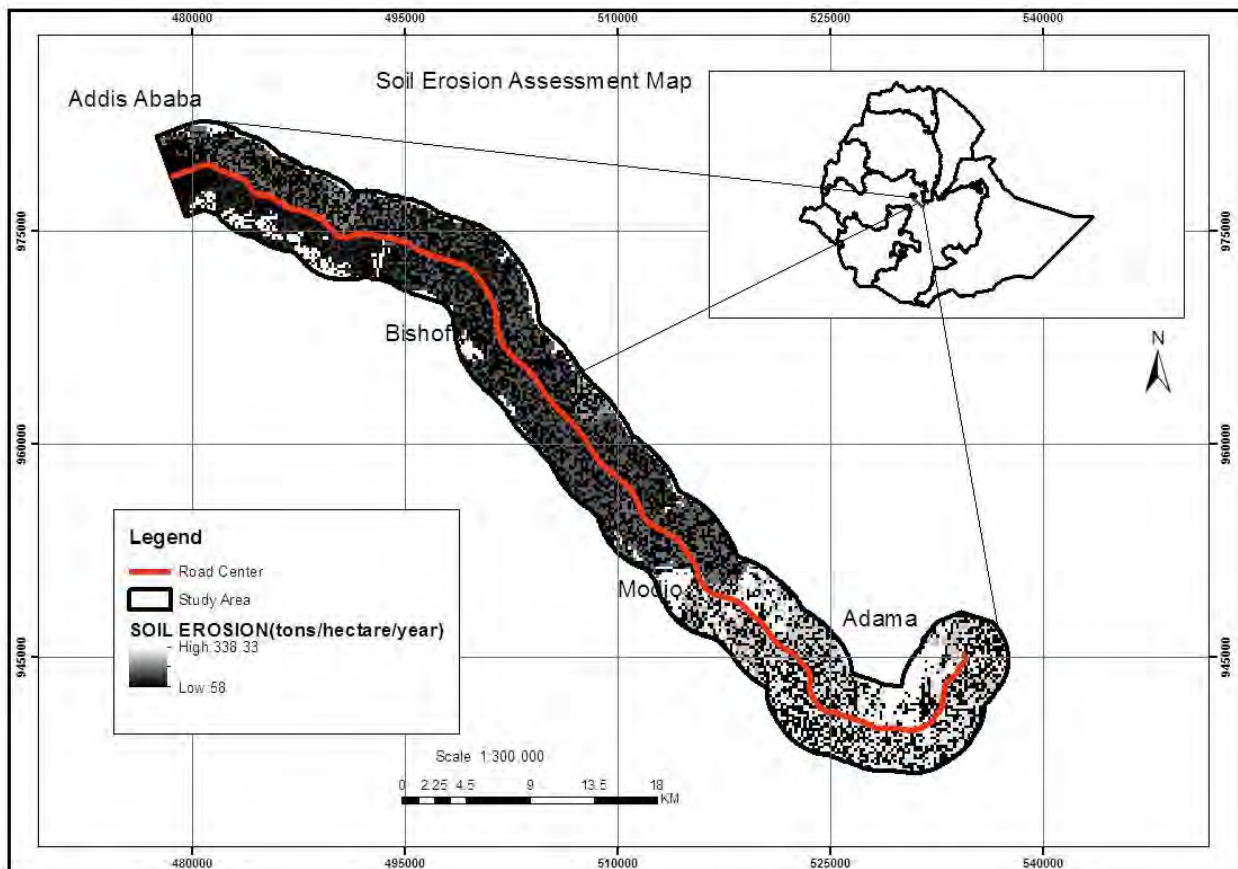


Figure 5.1: Assessment of soil erosion extent within the study area.

Multiplying the respective RUSLE factor values in Arc GIS 10.2.2 using the above formula shows a raster value of high and low. The highest raster values indicate areas that are extremely vulnerable to soil erosion where annual soil loss “E” is greater than 18 tons/hectare/year which is the normal soil loss tolerance (SLT) for Ethiopia and lowest raster values indicate areas that are less vulnerable to soil erosion comparatively yet still greater than the specified SLT.

6. DISCUSSION

6.1 MODEL RESULT DISCUSSION

The modeling results showed that bare lands and river banks within the study area are highly degraded due to soil erosion and are still vulnerable to severe and irreversible erosion. In addition, steeper slopes within Eutric - Vertisols of most crop lands are also susceptible to erosion. This implies that the express way is exposed to a possible threat imposing disintegration of the asphalt and sub grade as a result of Rill erosion, in particular within areas vulnerable to erosion unless soil conservation measures are employed as soon as possible. Land degradation due to severe erosion within the surrounding of the Express way is an intimidation to its sustainability which on the other hand can be avoided by development of Environmental functions of the road side particularly.

The extent of soil erosion at the study area is directly related to the integrity of the road network which is composed of the road corridor and its road side development with the surrounding landscape. This is owing to the fact that failure of the soil due to erosion may affect the road network of the Express way resulting into serious damages to the structural and asphalt work. Thus to prevent further degradation and loss of productive soil resources as well as achieve environmental quality and hazard protection of the critical and sensitive water bodies located within the study area professionals need to interact with all stakeholders and policy makers to ensure that the problems on the road needs to be assessed and managed sustainably as soon as possible.

A developed road side needs to have optimum natural resource conservation and landscape management interventions based on which its operational, environmental, visual and auxiliary functions are provided. Component of a natural resource, the land, upon which these interventions and landscaping are carried out, is the soil. Soil is the foundation of life and civilization on this planet to which living and non-living things are connected and dependent upon.

Moreover, the Dengora, Gogecha, Dukem, Bekenisa, Modjo and Golja rivers are crossed by the Express way at different points creating opportunity for ecological and sustainable scenic views to and from the surrounding landscape. Especially during the rainy season's soil and water preventive measures must be taken to improve the water quality of the rivers and streams by capturing rainfall and reducing erosion and runoffs. Until very recently, the presence of rivers and small streams within the scope of municipal developments is seen as an obstacle to construction rather than for ecological integration and opportunity to increase aesthetic values. They are used to be considered as garbage disposal areas where most built infrastructures dump their solid and liquid wastes.

Buildings, especially, are used to settings where they face rivers on their rare side. It is quite similar with construction of roads, ditches, culverts and bridges where rivers and streams are crossed. With such a trend, rivers and streams are most often neglected where storm water runoffs are damped into simply if spared from being a garbage bin. Therefore, it is mandatory that such trend be reversed and river and stream crossings be considered as an opportunity to maximize aesthetic scenic views. In addition, environmental measures need to be taken to prevent soil erosion at cut and fill batters, culvert inlets and outlets, bridges, interchanges, overpasses and underpasses. Tree planting enforcing the existence of farm lands and grass lands can be used to create a landscape that contributes to the quality of journey and the quality of the corridor. Ecological succession of more native trees such as “Kosso” and”Girar” is advisable for their morphology is adaptive to the existing nature of the climate as seen during field observation. Planting buffer trees along the rivers crossed by the Express way will also provide shade and cooling of streams, which is essential to aquatic life existence.

Road side restoration for the existing problem of the express way is mandatory which involves planning, design, construction and maintenance activities to restore the road side plant communities according to a designated road side character which may be operational(prepared, set and equipped),auxiliary(support and supplement), visual(aesthetic and illustrative) and environmental(ecological and green).Thus a context sensitive local landscape development as part of road side restoration for the Express way is mandatory where impact mitigation procedures for natural resource conservation and landscape management must clearly be identified and measured against standardized outputs.

7. CONCLUSIONS

7.1 CONCLUSIONS SPECIFIC TO THE EXPRESSWAY

Road side development for the express way is limited to the traditional type and does not address context sensitive and critical issues of its landscape. As a result, vulnerability for severe soil erosion is very high within the surrounding landscape of the express way.

Soil Erosion is a threat to the Express way unless soil conservation practice is employed.

One of its kinds in Ethiopia, the road side for the express way accommodates appropriate operational functions. However, auxiliary and visual functions deeply integrated within environmental functionality are far from achieved.

Road side restoration of the Express way specific to its environmental functionality is mandatory to integrate the road and its surrounding landscape sustainably as part of the major road network in Ethiopia. It requires re vegetation to provide slope stabilization of the cut and fill batters, erosion control of the bare lands, bio filtration and infiltration to improve quality of the minor water bodies, local climate modification by preserving native trees, woodlands and forests and screening the traffic while buffering its noise from the neighboring residents inside the condominium houses and private owned residences within the outskirts of Adama.

Sustainability of the Express way is highly dependent upon the implementation of its road side development and landscape management within its right of ways and beyond for peculiar, critical and sensitive issues of its landscape.

7.2 GENERAL CONCLUSIONS

There is lack of conventional understanding concerning the definition and extent of road side development between all stake holders of the Express way. The definition and extent of road side development and landscape management is not understood the same with all stakeholders having a key role to its practicality. These stakeholders are the construction contractor, the Federal and Regional administration officials, the public, planner, environmentalist and financiers.

The scope of Environmental Impact Assessment (EIA) within major road transportation developments in Ethiopia lacks efficiency due to the fact that the impact mitigation procedures are generic and overview to the impact assessed and do not prioritize and address nature and extent of impacts clearly with practical parameters and breakdown of costs to measure. There is also serious gap in monitoring the implementation of EIA plans by different sectors and private investors.

8. RECOMMENDATIONS

8.1 RECOMMENDATIONS SPECIFIC TO THE EXPRESS WAY

Minor water bodies, cut and fill batters including culverts and ditches, bare lands susceptible to severe erosions surrounding the Express way should be identified and rehabilitated and this will help for determination of mitigation and environmental compensation measures as part of the impact mitigation procedures(IMP).

A water shade unit plan within the study area is mandatory where runoffs from rain are collected and drained through a confluence point. It is a reliable remedial measure to rehabilitate the natural resources such as the soil, water and vegetation.

The result of erosion vulnerability may further be calibrated to prioritize soil conservation management using IKONOS satellite images of 5 meters Digital Elevation Model upon which statistical and qualitative RUSLE model is produced.

The study area is 48,163.2 hectares where about 200 -500 hectare sub-watersheds can be recommended to be part of a larger community watershed. These watersheds should be identified and prioritized for key interventions.

However, larger size watersheds will be more appropriate and effective within the study area because upper side of the catchment area is particularly in drier areas where villages are scattered. This is typical to the area between Modjo and Adama.

In addition, the development of these watersheds should be made participatory but not only to the public but all stakeholders for its sustainability. It can have short term and long term benefits dependent upon the interaction between land use and land capabilities.

Proposing for the following actions to be taken –

- ❖ Soil and water preventive measures must be taken to improve the water quality of the rivers and streams by capturing rainfall and reducing erosion and runoffs during the rainy season. Bio filtration swales and strips may be designed and constructed to capture biologically degrading pollutants carried by storm water runoffs and reduce its velocity. Bio engineering techniques such as vitiver grass planting can prevent landslides and slope stabilization at cut and fill batters of the Express way. This is mandatory to ensure the sustainability of the road corridor.

8.2 GENERAL RECOMMENDATION

Conventional agreement on the definition and extent of environmental functions of road side development and landscape management should be made between all stakeholders in Ethiopia.

Detailed field survey to identify status and nature of a landscape and its environs where major developments are planned to take place is mandatory within the planning frames before design, construction and maintenance of an infrastructure is carried out. Habitats of specific nature and location found within the scope of any infrastructure development should be conserved, rehabilitated and regenerated.

Federal legislation and directives with impact mitigation procedures for nature conservation and landscape management should be enforced within the Road side development practices within Ethiopia.

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