# Geomorphological Instigated Runoff Water and Soil Erosion of Ashebeka Watershed, Digalu Tijo District, Arsi Zone, Oromia, Ethiopia

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**Abstract**
Watershed is a landform connected by ridges that descend into lower elevations and small valleys, thus carries rainwater into soil, rivulets and streams then flowing into large rivers. The soil in Ashebeka watershed is being eroded and the accusing finger is to geomorphological agents. This study is aimed to estimate geomorphological caused surface runoff water and soil erosion of Ashebeka watershed. Ashebeka watershed in Digalu Tijo district was purposively selected since it is providing drinking water for Asella town and one of rift valley lake called Zuway. It is also a source of water for small scale irrigation and domestic uses of communities in watershed. Clustering Ashebeka watershed in to five milli-watershed 22 householders from each of them, those are110 in total, were randomly selected for interviews. Data estimated by using universal soil loss algorism, and collected from field observation and householders' interview were analyzed by using descriptive statistics. Majority 70.1% of Ashebeka watershed was covered by farmland. The watershed was producing 31,175.1 m3/hr of excess runoff water from this 74.9% were produced by farmland. The estimated average annual erosion rate per unit area of Ashebeka watershed were high in settlements (3.0776 ton/ha/year) and farmland (1.0664ton/ha/year). The estimated annual soil loss from overall area of the watershed were 9,521.1 tonnes/year. From this 84.8% of sediments, affecting Asella town drinking water reservoir, were produced by farmland. The adverse effects of surface runoff water on road and other infrastructure, crop and sedimentation at reservoir during rainy season, and decrease in river discharge and livestock production in dry season were significantly high. This adverse effects of surface runoff water and rate of soil loss have been increasing due to lack of proper land management practices. As a result, construction of physical and biological soil and water conservation structure in the watershed is convenient.
**Keywords:** Geomorphological agent, Runoff, Soil erosion, Watershed

## 1. Introduction

A watershed is a topographically delineated area where a runoff resulting from drops of rain will be collected and drained through a common confluence point. The confluence point is a single body of water, such as a lake, river or simply a watershed outlet. All watersheds contain many kinds of natural resources - soil, water, forest, rangeland, wildlife, minerals, etc. Geomorphic agents, like surface runoff water, wind, topography, land cover, Gravity and drainage pattern are often useful in universal soil loss estimation. The watershed with larger drainage density, relief ratio and slopes transfer rain water more quickly to the outlet of the watershed. Stream order characterizes the basin in rank from extremely small, first order streams at high elevations to the major, high-order streams in complex drainage networks (Fereres and Kassam, 2003). Water is the greatest resource to human beings. Socioeconomic development and the civilization of human beings are closely associated to man's ability to utilize and control water resources. Water serves as a positive input for many activities. It meets essential biological needs or basic element of socioeconomic infrastructure. It serves as a natural amenity contributing to psychological welfare.

In contrast, the natural resource is still being destroyed at an alarming rate. Watershed degradation results from the interaction of physiographic features, climate and poor land use: deforestation, inappropriate cultivation, disturbance of mining, the movement of animals, road construction, and badly controlled diversion, storage, transportation and use of water. Watershed degradation can be changes in the quality, quantity and timing of hydrological behavior like river flow. Water also serves in negative roles such as flooding and diseases transmission (FAO, 2006). Major natural disasters, most notably the drought and the loss of coastal and river floods, have brought the subject of water onto the world stage in recent years.

Soil erosion are considered as the worst problem due to the permanent damages caused to the watershed. Erosion is the detachment of particles of soil and surficial sediments and rocks caused by hydrological processes of sheet erosion, rolling and gully erosion, and through mass wasting and the action of wind erosion. Sedimentation is the processes of erosion, transportation, deposition and the compaction of sediment. These are natural processes that have been active throughout geological times and have shaped the present landscape of our world (Kerr and Chung, 2001). The major external dynamic agents of sedimentation or erosion are water, wind, gravity and ice. Soil erosion reduces the levels of the basic plant nutrients needed for crops, trees and others plants, and decreases the diversity and abundance of soil organisms. Soil erosion is an important social and economic problem and an essential factor in assessing ecosystem health and function. Sediment yield from watershed is that portion of the eroded soil which leaves the basin (Perez and Tschinkel, 2003). Thus, Erosion is the loosening or dissolving and removal of earthy or rock materials from any part of the earth surface.

The real need is to forecast future conditions, and yet the material presented herein focuses on hind casting a historical period. That is because land use, rainfall, and runoff are known for hind casting. In forecasting future yields, all runoff and soil erosion parameters must be estimated. Estimation of runoff and soil erosion is essential to issues of land and water management, including sediment transport and storage in lowlands, reservoirs and irrigation systems. The actual and potential linkages between land and water management and poverty are, however, complex and likely to be site specific and scale dependent (Swallow *et al.,* 2006). Integrated natural resource management are the main aims of community service project of Arsi University. It is the process of formulating and carrying out a course of action involving the manipulation of resources in a watershed to provide goods and services without adversely affecting the soil and water base. Usually, watershed management must consider the social, economic and institutional factors operating within and outside the watershed area (Bewket and Teferi, 2009).

## 2. Materials and Methods

### 2.1. Description of the watershed

#### 2.1.1. Geographical location of Ashebeka watershed

The Ashebeka watershed is found in Degelu Tijo district (Woreda) of Arsi Zone, Oromia reginal state. The watershed is geographically located at latitude and longitude of 07°47′49″N to 7°%54'17"N and 39°17′11″E to 39°24'56''E respectively (figure-1).

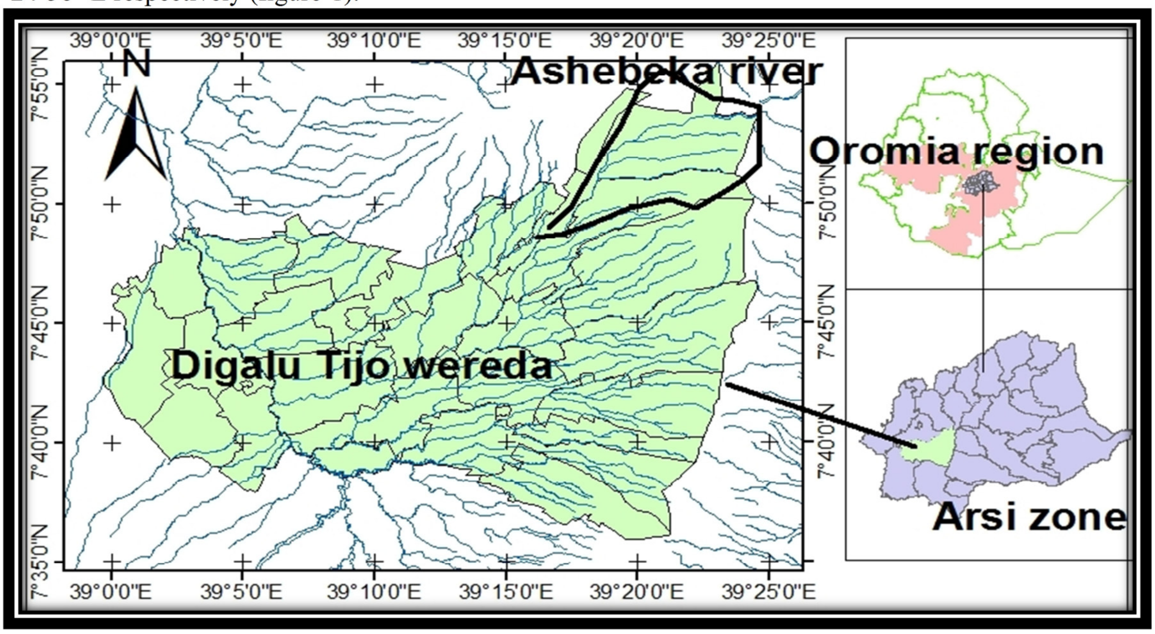


Figure 1: Map of study area

#### 2.1.2. Biophysical characteristics of Ashebeka watershed

According to traditional agro-climatic classification of Ethiopia, the Ashebeka watershed are found in Dega agro-climatic zone with elevation ranges from 2700- 3800m asl. The mean annual temperature ranging from 11 to 20 °C. The soil in the watershed are red nito-soil and black verti-soil. Most parts of watershed receive sufficient to high rainfall (1800 - 2700mm) during the main rainy season of the country (summer). The land use and land cover of the watershed are dominated by farm land, forest, grazing land and settlement (figure-2). *Juniperus procera, Olea africana* and *Hagenia abyssinica* are those dominantly grown indigenous trees species in the watershed.

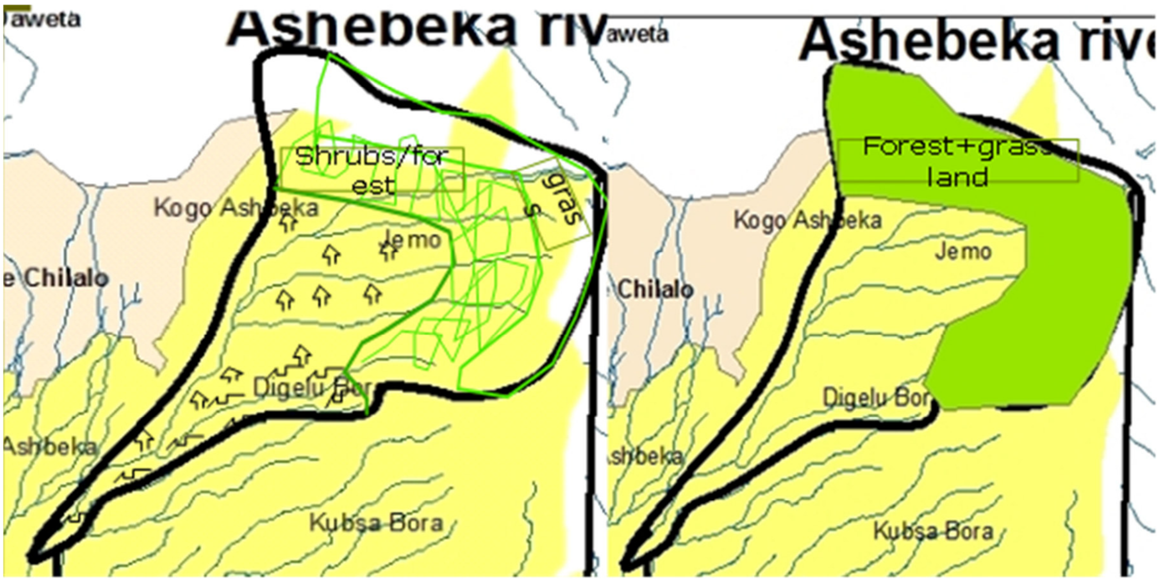


Figure 2: Land use and land cover of the watershed

### 2.1.3. Socioeconomic characteristics of Ashebeka watershed

According to peasant association or kebeles' leaders, which is the lowest administration level in Ethiopia, more than 2545 householder are found in four kebeles of Ashebeka watershed namely; Kogo Ashebeka, Jemo, Digalu Bora and Digalu Kideme kebeles. The communities in Ashebeka watershed live on mixed farming system (livestock and crop farming). The watershed has a bimodal rainfall distribution that is being used for crop production. The main wet period named "kiremt" extends from June to October and a short rainy period termed "Belg" occurring between March and June.

## 2.2. Methods of site and respondents selection

### 2.2.1. Methods of site selection

The Digalu Tijo district and its Ashebeka watershed were purposively selected since the watershed providing drinking water to Asella town is in focused of community service project of Arsi University. Ashebeka watershed has too large area to manage in a year. Thus to make manageable it has been clustered in to five milli-watershed as indicated in (table-1). Finally from its five milli-watershed, Arole ude milli-watershed was purposively selected for soil and water conservation by community service project of Arsi University based on suitability to reach easily, severity, and amount of allocated budgets. It is also the milli watershed whose upstream dominantly covered by farmland. Its sediment of soil erosion is immediately affecting Asella town drinking water reservoir. It is a source of water for domestic use and irrigation of communities live in watersheds as well. The chilalo Gelama's wildlife is also depend on watersheds for places to live and nest.

Table 1; Sub division of Ashebeka watershed

| NO | Milli watershed | Micro watershed | Total area (hek) | % |
|---|---|---|---|---|
| | Bottom Ashabeka | Helensa | 800 | 7.4 |
| 1 | (1360hek) | Ashabeka riverside | 560 | 5.2 |
| | Guracho 1920hectar) | Jemo | 320 | 3 |
| | | Larger Goda hetosa | 650 | 6 |
| | | Smaller Goda hetosa | 400 | 3.7 |
| 2 | | Korke | 550 | 5.1 |
| | | Tulu saden | 490 | 4.5 |
| | Tulushebeka (4200hek) | Larger ashebeka | 1180 | 10.9 |
| | | Ashebeka | 390 | 3.6 |
| | | Northern Smaller ashebeka | 1050 | 9.7 |
| 3 | | Southern Smaller ashebeka | 1090 | 10.1 |
| | Udeguchi (1870hek) | Northern guchi | 270 | 2.5 |
| | | Larger guchi | 1100 | 10.2 |
| 4 | | Northern ude | 500 | 4.6 |
| | Arole ude (1450hek) | Aroye | 450 | 4.2 |
| 5 | | Ude | 1000 | 9.3 |
| | Total area | | **10800hek** | 100 |

**2.2.2. Methods of respondent selection**

First of all those kebeles (the lowest administration unit in Ethiopia) in Ashebeka watershed were identified by GIS. The list of households were obtained from kebeles office then they were stratified in to five milli watershed (table-1). Finally, 22 householders from each of five milli-watershed, those are110 in total, were randomly selected for interviews. Since the land use and land cover of all five milli-watershed are similar it is not economical to select anymore respondents.

**2.3. Method of data collection, runoff and Soil erosion estimation**

**2.3.1.** Method of data collection

Both primary and secondary data were collected for the study. Primary data were collected through the use of watershed observation, and householders' interview. The sources of secondary data were unpublished written documents including annual reports and other unpublished documents. The main interview questionnaire focused on impacts of runoff water and soil erosion. Generally, attention was given to estimate excess runoff water and soil erosion, as well as to identify their major problem which was understood by farmers as the problems affecting the capability of lands for crop and livestock production.

**2.3.2. Methods of runoff flood estimation**

Various methods can be used to estimate the runoff rate. The following rational formula is the simplest method for determining peak discharge of watershed runoff water. The calculation was done using the rainfall intensity, area of watershed, and runoff coefficient (USDA-ARS, 2008a).

$Q = \frac{C*I*A}{360}$ ------------------------------eq-1

Whereas:

Q = rate of runoff in m3/hr, I = rainfall intensity in mm/hr for a designed frequency and a duration or time of concentration, A = area of watershed in ha, and C = dimensionless runoff coefficient. The rational runoff coefficient (C) is a function of the soil type and drainage basin slope (table-2). The rainfall intensity (I) is typically found from intensity/duration/frequency curves for rainfall events in the geographical region of interest. The duration is usually equivalent to the time of concentration of the drainage area. The value of the rational method runoff coefficient can vary from close to zero to one. A low C value indicates that most of the water is retained for a time on the ground surface and soaks into the ground, where as a high C value means that most of the rainwater runs off immediately.

Table 2 Rational runoff coefficients (C) for different slop, land cover and soil types

| Land use and topography | Soil type | | |
|---|---|---|---|
| | Sandy loam | Clay and silt loam | Tight clay |
| Cultivated land | | | |
| Flat | 0.30 | 0.50 | 0.60 |
| Rolling | 0.40 | 0.60 | 0.70 |
| Hilly | 0.52 | 0.72 | 0.82 |
| Pasture land | | | |
| Flat | 0.10 | 0.30 | 0.40 |
| Rolling | 0.16 | 0.36 | 0.55 |
| Hilly | 0.22 | 0.42 | 0.60 |
| Forest land | | | |
| Flat | 0.10 | 0.30 | 0.40 |
| Rolling | 0.25 | 0.35 | 0.60 |
| Hilly | 0.30 | 0.50 | 0.60 |
| Populated area | | | |
| Flat | 0.40 | 0.55 | 0.65 |
| Rolling | 0.50 | 0.65 | 0.80 |

**2.3.3. Methods of Soil erosion estimation**

Rates of soil erosion can be estimated using erosion prediction equations developed during the last four decades. Among these algorithms the Universal Soil Loss Equation (USLE) and its recent updated the Revised Universal Soil Loss Equation (RUSLE) or Modified University Soil Equation (MUSLE) can be used. Thus Universal soil loss equation (USLE) was used for this study to estimate the average annual soil loss (A) by multiplying a number of issues collectively, which includes: rainfall erosivity factor, soil erodibility factor, slope length and steepness factors; crop management factor and support practice factors (eq. 2). According to (USDA-ARS, 2008b) the USLE is a function of the following factors.

A = R*K*L*S*C*P ----------------------------------eq-2

Where,

A = estimate gross soil erosion, t/ha/year

 

R = rainfall erosive factor, joules/(ha/year), (t-m/ha) (mm/h) per year
K = Soil erodible factor (t/ha), t/joules, t/ha-year
L = Slope length factor
S = Slope gradient factor
C = Crop cover or crop management factor
P = Supporting conservation practice factor

**2.3.2.1. Rainfall Erosive Index (R-Factor)**

According to USLE the magnitude of surface soil erosion is directly related to the intensity of precipitation (Paudel, and Andersen, 2010). R-factor is a function of storm kinetic energy and the maximum thirty minutes rain fall intensity. The differences in R factor represent differences in erosivity of the climate mainly rainfall. The R factor of Ashebeka watershed was determined using formula given below (Foster *et al*., 2000).

R=79+0.363*rf--------------------------------------------eq-3

Where,
R= Annual R factor,
rf= Average annual rainfall in mm.

**2.3.2.2. Soil erodible (K) factor**

Soil texture is the main determinants of K-factor as compared to its structures, organic matter and permeability. A particle size analysis to determine the fraction of sand, silt and clay is used to estimate K-factor. The soil erodible factor is measure of the vulnerability of soil particles to detachments and transport by rainfall and runoff. The determination of the K values should be based on the soil exposed during the critical rainfall months.

Table 3: Soil erodibility (K) factor for different soil groups

| No. | Order | Soil Sub Group | K factor |
|---|---|---|---|
| 1 | Inceptisols | Lithic Ustorthents | 0.2635 |
| 2 | Inceptisols | Vertic Ustochrepts | 0.3386 |
| 3 | Entisols | Typic Ustifluvents | 0.1261 |
| 4 | Inceptisols | Typic Ustochrepts | 0.3378 |

**2.3.2.3. Slope length and steepness (L & S) factors**

$L = \frac{(Lp)^m}{22.13}$ --------------------------------------------eq-4

Where
L= is slope length factor
Lp = The actual unbroken length of the slope (meters) measured up to the point where the overland flow terminates, and m is an exponent which is determined by slopes (Stone, and Hilborn, 2000). Accordint to (Tiwari, *et al*., 2000) the following formula is used to determine *S* factor:

$S = \frac{(0.43+0.306+0.043s^2)}{6.613}$ ----------------------------------eq-5

Where
S= is slope steepness factor
s = the slope of the field plot (%).
Thus Ashebeka watershed has the following values o L and S factors (table-4).

Table 4:Slope length and steepness factors

| L and S-factor map | | Study area | | |
|---|---|---|---|---|
| **Slope steepness** | **'m' expon** | **Land cover** | **L - Factor** | **S - factors** |
| 4% | 0.4 | Farmland | 0.113 | 0.215 |
| 8% | 0.5 | Forestland | 0.142 | 0.527 |
| 7% | 0.5 | Grazing land | 0.142 | 0.43 |
| 3% | 0.3 | Settlement | 0.09 | 0.17 |
| 3% | 0.3 | Wetland/river | 0.09 | 0.17 |
| Remark | | | Eq-4 | Eq-5 |

**2.3.2.4. Cover management (C) factor**

Cover management (C) factor is the ratio of soil loss from watershed with specified cover and management. C-factor map shows that the area with higher vegetation cover will restrict soil erosion. The values of C-factor of Ashebeka watershed is shown as following (table-5).

Table 5 Average values of cover management factors

| | C-factor map | | | Study area | |
|---|---|---|---|---|---|
| **No** | **Level-I** | **Level-II** | **C-Factor** | | |
| 1 | Agriculture | Double Crop | 0.4 | **Land cover** | **C-Factor** |
| | | Single crop | 0.5 | Farmland | 0.34 |
| 2 | Waste Land | Land Without Scrub | 0.8 | Forestland | 0.001 |
| | | Land With Scrub | 0.95 | Grazing land | 0.001 |
| 3 | Settlement | Urban & Rural | 0.2 | Settlement | 0.4 |
| 4 | Water Bodies | River | 0 | Wetland/river | 0.001 |
| | | Reservoir/Stream | 0 | | |
| 5 | Plantation | Plantation | 0.1 | | |

#### 2.3.2.5. Support practice (P) factor

The P-factor mainly represents how surface conditions affect flow paths and flow hydraulics. It is the ratio of soil loss with specific support practice; such as contouring, strip cropping, terracing and subsurface drainage, to the corresponding loss with up and slope tillage. The P-factor of Ashebeka watershed is an expression of the effect of specific land use and cover in watershed as shown in the following (table-6).

Table 6 Conservation practice factor on different slope gradients

| P-factor map | | Study area | |
|---|---|---|---|
| **Land uses** | **P-factor** | **Land cover** | **P-factor** |
| Agricultural land | 0.4 | Farmland | 0.4 |
| Built-up land | 1 | Forestland | 0.1 |
| Tree clad area | 0.1 | Grazing land | 0.1 |
| Waste land | 1 | Settlement | 1 |
| Water bodies | 0.5 | Wetland/river | 0.5 |

### 2.4. Method of data analysis

Those data estimated by using USLE and collected from site observation and household's interview was entered into Statistical Package for Social Science (SPSS) version 22. The results was analyzed by using descriptive statistics. Most of data gathered obtained from watershed observation and households interview were also used to interpret the estimated data by using USLE. The final results were organized and represented by using tables and figures.

## 3. Results and Discussion

### 3.1. Geomorphological characteristics of the watershed

#### 3.1.1. Physiological classification of Ashebeka watershed

A watershed is a basin like landform defined by peaks which are connected by ridges that descend into lower elevations and small valleys. It carries rainwater falling on it drop by drop and channels into soil, rivulets and streams flowing into large rivers (Perez and Tschinkel, 2003). Ashebeka watershed has large area (10800ha) which is unmanageable in a year. To make it to be manageable it has been clustered in to five milli- watershed consists of sixteen micro watershed based on area and its tributes namely: Bottom Ashabeka, Guracho, Tulu Ashebeka, Udeguchi and Arole ude. It supplies water for one of rift valley lake called Zuway (Hara Dembal). It provide water for small scale irrigation and domestic uses of communities in watershed. The watershed is also a source of drinking water for Asella town which is the capital town of Arsi administration zone. From total area of Ashebeka watershed 57.4% highly exposed to soil erosion (table-7) because it is dominantly covered by poorly managed and steep farmland. In line to this finding Silburn, and Hunter (2002) reported that socioeconomic development and the civilization of human beings are closely associated to man's ability to utilize and control watershed resources.

Table 7; Erosive area of Ashebeka watershed

| NO | Milli watershed | micro watershed | Total area (hek) | Erosive area (hek) | % |
|---|---|---|---|---|---|
| 1 | Lower Ashabeka (1360hek) | Helensa | 800 | 527 | 65.9 |
| | | Ashabeka riverside | 560 | 416 | 74.3 |
| 2 | Guracho 1920hectar) | Jemo | 320 | 320 | 100 |
| | | Larger Goda hetosa | 650 | 358 | 55.1 |
| | | Smaller Goda hetosa | 400 | 400 | 100 |
| | | Korke | 550 | 450 | 81.8 |
| 3 | Tulushebeka (4200hek) | Tulu saden | 490 | 296 | 60.4 |
| | | Larger ashebeka | 1180 | 480 | 40.7 |
| | | Ashebeka | 390 | 200 | 51.3 |
| | | Northern Smaller ashebeka | 1050 | 150 | 14.3 |
| | | Southern Smaller ashebeka | 1090 | 412 | 37.8 |
| 4 | Udeguchi (1870hek) | Northern guchi | 270 | 270 | 100. |
| | | Larger guchi | 1100 | 420 | 38.2 |
| | | Northern ude | 500 | 500 | 100. |
| 5 | Arole ude (1450hek) | Aroye | 450 | 450 | 100 |
| | | Ode | 1000 | 550 | 55 |
| | **Total area** | | **10800** | **6199** | **57.4** |

### 3.1.2. Land use and land cover of Ashebeka watershed

Five major types of land use and land cover of the Ashebeka watershed were already identified by farmers. Huge area coverage of Ashebeka watershed has been dominated by farm land 70.1% and followed by its Chilalo Galema mountain natural forest (14.9%). Majority of its Arole ude milli- watershed is covered by farmland (68%) that dominated by (91.3%) of Red nitosoil (table). Majority of the forest and grazing land in Arole ude milli-watershed is found at steep area. Its farmlands have relatively higher soil depth. The minimum observed soil depth of Arole ude milli- watershed was 5cm which is found in drainage mainly river (table-8 & figure-2). Similar land use and land cover classification was also reported by Nunes, et al. (2011), and Naiman (1992) who described the most complex type of natural system in watershed such as physical, biological, traits and behavior of natural systems, and watershed structure and function. In watershed terms, land cover change can also a process that circulate the watershed's energy, water and materials from the biotic forestland, back into the abiotic bare land and from one set of predominant organisms on to a subsequent set of dominant organisms (Johnson and Van Hook, 1989). Similarly according to (Berendse, et al., 2015) the land cover type present in each watershed can be forest, shrublands, tundra, grasslands, and developed land types, including cropland, mosaic and built-up areas and water.

Table 8: Land use and land cover of Ashebeka watershed

| land use/cover | Overall area of Watershed | | Arole Ude milli-watershed (Watershed's under rehabilitation) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Arole Ude Milli--w'shed | | Soil characteristics | | | |
| | Area (ha) | % | Area (ha) | % | Mean Slop % | Bed soil% | Black soil% | Minimum soil depth |
| Farm land | 7570 | 70.1 | 986 | 68 | 4 | 91.3 | 8.7 | > 50cm |
| Forest land | 1610 | 14.9 | 162 | 11.2 | 8 | 91 | 9 | >17cm |
| Grazing land | 1040 | 9.6 | 176 | 12.1 | 7 | 78 | 22 | >22cm |
| Settlement | 470 | 4.4 | 107 | 7.4 | 3 | 87 | 13 | >50cm |
| Wetland | 110 | 1 | 19 | 1.3 | 3 | 94 | 6 | >5cm |
| Total area | 10800 | 100 | 1450 | 100 | | | | |

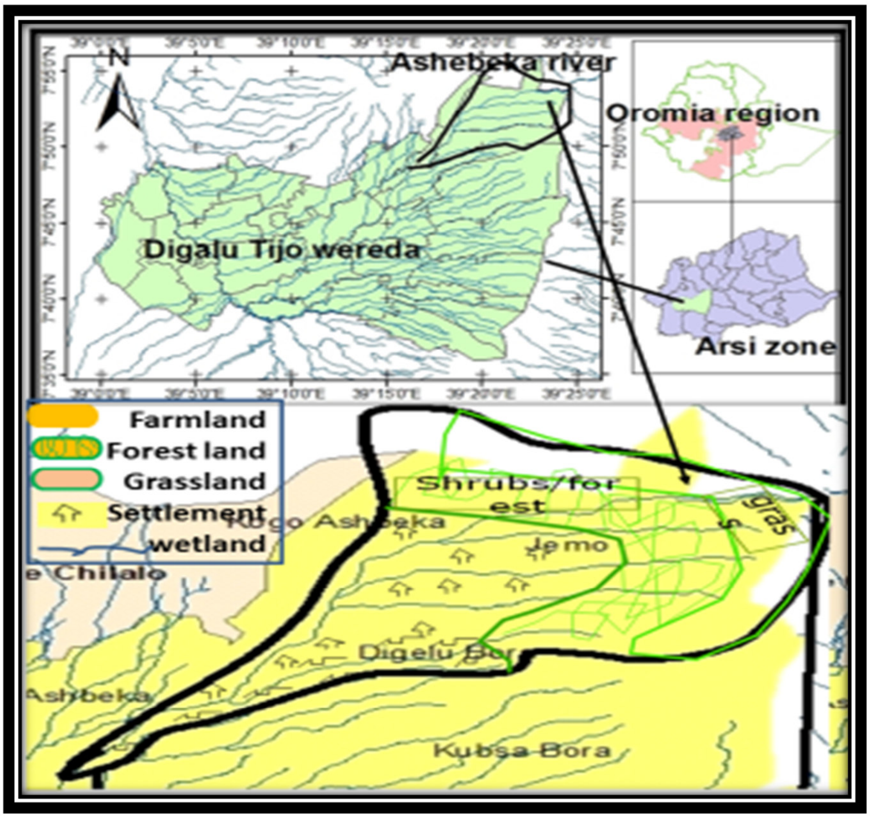


Figure 3: Base map of land use classification

### 3.2. Runoff water and soil erosion

#### 3.2.1. Watershed's peak surface runoff water

Surface runoff occurs when rainfall rate is greater than infiltration rate. The permissible velocity of runoff water in a watershed varies with the type, condition, and density of vegetation. Ashebeka watershed has been producing (31,175.1 $m^3$/hr) of surface runoff water from which 74.9% were from farmland. Its Arole ude milli-watershed has been producing (4,174.7 $m^3$/hr) of Surface runoff water from which the higher amount (72.8%) were from farmland that have lower surface roughness. Thus runoff in this case is a part of rainfall that flows towards Zuway lake through Keter river basin mainly from farmlands of Ashebeka watershed as surface or subsurface flow. Inline to this finding Nyssen, et al. (2006) reported that a flow velocity in watershed depends upon factors such as the soil type, water quality, and ability of the vegetation to resist erosion. Similarly methods of runoff water estimation was also reported by Abate, (2011): **the** peak or maximum amount of discharge can be computed using different methods such as rational method, empirical formulas, unit hydrograph, flood frequency analysis.

Table 9: Algorism estimation of surface runoff water of Ashebeka watershed

| The land use and land cover | | | Estimated runoff water produced ($m^3$/hr) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | **Ashebeka watershed** | | | **Arole ude milli-wshed** | | |
| | **RF/I** | **C** | **Area (ha)** | **Runoff** | **%** | **Area (ha)** | **Runoff** | **%** |
| Farm land | 1850 | 0.6 | 7570 | 23340.8 | 74.9 | 986 | 3040.2 | 72.8 |
| Forest land | 1850 | 0.5 | 1610 | 4136.8 | 13.3 | 162 | 416.3 | 10.0 |
| Grazing land | 1850 | 0.36 | 1040 | 1924.0 | 6.2 | 176 | 325.6 | 7.8 |
| Settlement | 1850 | 0.65 | 470 | 1569.9 | 5.0 | 107 | 357.4 | 8.6 |
| Wetland | 1850 | 0.36 | 110 | 203.5 | 0.7 | 19 | 35.2 | 0.8 |
| Total area | | | 10800 | 31,175.1 | 100 | 1450 | 4174.7 | 100 |
| Remark | | Table2 | | eq-1 | | | eq-1 | |

Figure 4: Surface runoff water in Ashebeka watershed

### 3.2.2. Rate of soil erosion in Ashebeka watershed

As illustrated by soil loss estimation (table-2, 3, 5&6), the value of 'K', 'C' & 'P' factor of Ashebeka watershed were high in settlement and farmland. Whereas the value of 'L' & 'S' factors were high in forest and grazing land (table-4 and eq- 4&5). These factors map shows that the parts of watershed consists of high vegetation cover restricts the soil erosion in greater extent. The soil with more developed soil structures and higher infiltration has less erodible too. The average annual erosion rate per unit area of watershed was estimated by multiplying values of the other six factors (eq-2). The estimated average annual erosion rate per unit area of Ashebeka watershed were high in settlements (3.0776 ton/ha/year) and farmland (1.0664ton/ha/year). Whereas they were almost null in forest, grazing and wetland (table-10). Thus majority of soil erosion, causing sediments effects on Asella town drinking water reservoir (figure-6), were mainly produced by settlements and farmland. According to Maaoui, et al. (2012), Foster, et al. (2003) and USDA-ARS (2008a): when several samples is taken and analyzed separately differences in soil loss among different soil texture are detected on the large sites. Describing the universal validity of model Wall et al., (2002) explained the universal soil-erosion equation as a means of sediment prediction in a mirror of the intended six factors.

Table10: Estimated rate of soil erosion in Ashebeka watershed

| No | Variable | Types of land use and land cover | | | | | Remark |
|---|---|---|---|---|---|---|---|
| | | Farmland | Forest | Grazing | Settlement | Wetland | |
| 1 | Rainfall | 1850 | 1850 | 1850 | 1850 | 1850 | |
| 2 | R | 750.55 | 750.55 | 750.55 | 750.55 | 750.55 | Eq-3 |
| 3 | K | 0.43 | 0.18 | 0.13 | 0.67 | 0.01 | Table-2&3 |
| 4 | L | 0.113 | 0.142 | 0.142 | 0.09 | 0.09 | Eq-4 |
| 5 | S | 0.215 | 0.527 | 0.43 | 0.17 | 0.17 | Eq-5 |
| 6 | C | 0.34 | 0.001 | 0.001 | 0.4 | 0.001 | Table-5 |
| 7 | P | 0.4 | 0.1 | 0.1 | 1 | 0.5 | Table-6 |
| Rate of Erosion/Q (ton/ha/yr) | | 1.06636 | 0.00101 | 0.00060 | 3.07756 | 0.00006 | Eq-2 |

### 3.2.3. Overall soil loss from Ashebeka watershed

According to the elders, the rate of soil loss has been increasing due to overgrazing, removing crop residues and cow dung and vegetative cover from farmland for further agricultural expansion, fuelwood and other wood requirements. The estimated average annual soil loss from Ashebeka watershed and its Arole ude milli-watershed were 9,521.1 and 1,381tonnes/year respectively. From these majority (84.8%) and (76.1%) of Ashebeka watershed's and its Arole Ude milli- watershed's sediment respectively were also produced by farm land respectively (table 11). These soil loss were an estimate of the average annual sheet and rill erosion from rainfall on upstream area of watersheds but not include erosion from stream banks, gullies and/or wind. It also includes eroded and subsequently dumped sediment in other places of watersheds before reaching an outlet found at Asella town's drinking water reservoirs. The farmlands in watershed have lack of proper land management practices, contributing to high soil erosion hazard. Due to population pressure, it has been constantly cultivated with cereal crops mainly barley and wheat, while soil and water conservation was completely neglected. Furthermore, consumption of cow dung and forests as source of energy and construction material has instigated deforestation. Abate (2011) reported similar way of soil erosion estimation based on rainfall erosivity of six factor. Further, Bizoza (2014) also showed that soil disturbance by animal increases bulk density and compaction, reduce pore spaces and infiltration capacity, which ultimately increases runoff and soil erosion of settlement. This finding is also in agreement with research results elsewhere (Berhan and Mekonnen, 2009 and Vásquez-Méndez, *et al.*, 2010) those reported that forest and grasses land were less vulnerable to soil loss than farmland.

 

Table 11: Overall annual soil loss from Ashebeka watershed

| No | The land use and land cover | Erosion rate (ton/ha/yr) | Estimated erosion(tonnes/area of w'shed/year) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Ashebeka whed | | | Arole ude Milli- wshed | | |
| | | | Area (hec) | Erosion (ton/yr) | % | Area (hec) | Erosion (ton/yr) | % |
| 1 | Farm land | 1.06636 | 7570 | 8072.3 | 84.8 | 986 | 1051.431 | 76.14 |
| 2 | Forest | 0.00101 | 1610 | 1.63 | 0.02 | 162 | 0.164 | 0.012 |
| 3 | Grazing land | 0.0006 | 1040 | 0.62 | 0.007 | 176 | 0.106 | 0.008 |
| 4 | Settlement | 3.07756 | 470 | 1446.45 | 15.2 | 107 | 329.299 | 23.84 |
| 5 | Wetland | 0.00006 | 110 | 0.01 | 0.0001 | 19 | 0.001 | 0.0001 |
| | Total area | | 10800 | 9521.1 | 100 | 1450 | 1381 | 100 |
| | Remark | Table-10 | | Eq-2 | | | Eq-2 | |


Figure 5: Soil erosion in Ashebeka watershed

**3.3. Major effects of surface runoff water in** Ashebeka watershed
The effects of surface runoff water on Ashebeka watershed can be more than list however those farmers' understood and identified in their life experience are seven. From the lists the adverse effects of surface runoff water on physical damage to human and/or animal, and crop production, were low and moderate respectively. Whereas its effects on other factors in watershed were significantly high (table-12). Unsustainable livelihoods often contribute to degradation of important watershed resources (Bingner and Theurer, 2001) from which fresh water and soil fertility take the lead though they have significant socio-economic and ecological roles especially for Ethiopia where traditional agricultural-based economy is dominant. An extensive areas of agricultural lands in Ethiopia are eroded every year and most of these lands (cultivated and grazing) are changed in to gullies (Desta *et al.,* 2005). Most parts of the Ethiopia faces short and long term land degradation, which harms the ecosystem, livelihood and food security of the people (Zobeck *et al*., 2000).

Table 12: Major impacts of surface runoff water

| Effects | N | Mean | SD |
|---|---|---|---|
| Flooding effects on road/other infrastructure | 110 | 4.9182 | 0.30686 |
| Decrease in river discharge in dry season | 110 | 4.8364 | 0.47944 |
| Flooding effects on crop | 110 | 4.6727 | 0.59214 |
| Sedimentation at reservoir at rainy season | 110 | 4.6636 | 0.97940 |
| Reduction of livestock production | 110 | 4.2091 | 1.12597 |
| Reduction of crop production | 110 | 3.6818 | 0.87715 |
| Flooding effects on human and/or animal | 110 | 1.9818 | 0.85651 |

0= don't know, 1=very low, 2=low, 3=medium, 4=high, 5= has very high effects

 

Figure 6: Sedimentation effects at Asella town drinking water reservoir

## 4. Conclusion and Recommendation

Ashebeka watershed supplies water for small scale irrigation and domestic uses of communities in watershed as well as one of riftvalley lake called Zuway. The watershed is also a source of drinking water for Asella town which is the capital town of Arsi administration zone. From five major identified types of land use and land cover of Ashebeka watershed, large area (70.1%) was covered by farmland. This came up with rainfall rate to be greater than infiltration rate and thus producing excess runoff water (31,175.1 $m^3$/hr) of which 74.9% were from farmland. Runoff in this case is a part of rainfall that flows towards Zuway lake through Keter river basin mainly from farmlands of Ashebeka watershed as surface or subsurface flow. Arole ude milli-watershed of Ashebeka watershed was selected to be conserved initially by community service project of Arsi University. The estimated average annual erosion rate per unit area of Ashebeka watershed were high in settlements (3.0776 ton/ha/year) and farmland (1.0664ton/ha/year) as compared to forest, grazing and wetland. The estimated average annual soil loss from overall area of Ashebeka watershed and its Arole ude milli-watershed were 9,521.1 tonnes/year and 1,381 tonnes/year respectively. From these majority (84.8%) and (76.1%) of Ashebeka watershed's and its Arole Ude milli- watershed's sediment were also produced by farmland respectively. Thus majority of soil erosion of watersheds causing sediments effects on Asella town drinking water reservoir, were mainly produced by settlements and farmland. According to the elders, the rate of soil loss has been increasing due to overgrazing, improper farming system, agricultural expansion, fuelwood and other wood requirements. From the lists in table-12 the adverse effects of surface runoff water and soil erosion on infrastructure mainly road, crop and sedimentation at reservoir during main rainy season, and reduction in river discharge and livestock production in dry season were significantly high. Unsustainable livelihoods often contribute to degradation of important watershed resources providing vital socio-economic and ecological roles especially for communities. Hence, it is very important to construct different physical and biological soil and water conservation structure: mainly bunds and agroforestry practice in farmland, as well as Check dams and water harvesting structure for spring development in forest land found in Chilalo Galama natural forest.

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