Assessment of the Potential of Flood-Based Farming in Ethiopia

(Afar, Amhara, Benshagul Gumuz, Oromia, The Southern Nations, Nationalists and People Region)

Prepared by:

Daniel Teka (PhD)

Tesfa-alem Gebreegziabher

Ayele Almaw

GoitomTukue

and

Abity Getaneh

Spate Irrigation Network

Mekelle University

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1.0 Introduction

1.1 Background

Ethiopia is the second most populous country in Africa. At present the total population is estimated to reach 90 million (The world Factbook, 2012). Despite being the main source of the Nile, the longest river on earth, Ethiopia underwent a series of drought. Agriculture accounts the highest of the GDP (for almost 41%), though most cultivated land in Ethiopia is under rainfed.

In recent times the Government of Ethiopia (GoE) has embarked in the development of several water-harvesting schemes to alleviate the moisture stress for crop production. Flood-based farming is one of these developments (e.g. Mehari Haile et al., 2013) in which spate irrigation accounts the most. Spate irrigation is practiced in arid areas bordering runoff producing highlands. There is no accurate data on the area under spate irrigation globally, but estimates place it at 2.0-2.5 million ha. The report indicated that Ethiopia is one of country where there exists potential area for spate, with an area around 100,000 ha. Although its extent is relatively minor compared to other types of irrigation, it represents a unique option for the management of scarce water resources in support of agricultural production and rural livelihoods in many arid regions.

Spate irrigation is a form of water management that is unique to semi-arid environments, particularly where mountain catchments border lowlands. As such, short duration floods are diverted from river beds and spread over land-to cultivate crops, feed drinking water ponds, or irrigate pasture areas or forest land. Some spate irrigation systems in Ethiopia have been in use for several generations, but in almost all areas spate irrigation has developed recently (van Steenbergen*et al.,* 2011). Spate irrigation is on the increase in the arid parts of the country: in Tigray (Raja, Waja, Raya), Oromia (Bale, Arsi, West and East Haraghe), Dire Dawa Administrative Region, in SNNP, Southern Nations, Nationalities and Peoples Region (Konso), Afar and in Amhara (Kobe). Spate irrigation systems are practiced both in the midlands and lowlands in

Ethiopia. At present most spate systems are in the midlands and some in the lowlands. The area currently under spate irrigation in Ethiopia is estimated at 140,000 ha, but the potential particularly in the lowland plains is much higher (Alemehayu, 2008). This is important in Ethiopia to assure food security as sufficient food has to be produced to meet the requirements of a growing population that still substantially relies on food aid.

There are several ways to improve the potential benefits expected from the spate irrigation. However, to achieve this, the spatial extent of potential spate irrigation sites should be assessed. This helps to the systematic and effective introduction and expansion of flood-based farming into the plain areas of Ethiopia by identifying the potential and most promising areas for intervention. The study includes several multi-scale secondary data including soil, land use land cover, rainfall and topography.

1.2 Scope of the study

Several studies were conducted to assess the extent of flood-based irrigation in Ethiopia. However,theaerialextent of these irrigation systems is not reliably indicated. Hence the assessment of the area suitable for flood-based irrigation becomes crucial. However, such assessment at national level requires both primary and secondary data. Due to some limitation, this study assessed the potential area that can be irrigated using only spate. The potential area that can be irrigated through flood-based can be substantially large. However, additional investigations should be conducted after the results of this preliminary result.

1.3 Objective

The objective of the study is to assess the potential irrigable area using spate in Afar region, Amhara region, Benishangul-Gumuz region, Oromia region, and Southern Nations, Nationalities and People's Region (SNNPR). Unlike the previous studies (e.g.Mehari Haile et al., 2013), this study focuses on available secondary data and no field work was conducted to verify the findings in the field. However, it is assumed that the findings from this study should be refined with further field investigation and detail methods.In doing so this study can be used to establish a base line for the assessment of potential spate irrigation in Afar region.

2.0 Materials and Methods

2.1 Description of the study area

This study was conducted atfour regional states in Ethiopia: Afar region, Amhara region, Benishangul-Gumuz region, Oromia region and SNNPR.

The Afar region is located in the North Easter part of Ethiopia (Figure 1) bordered by Amhara and Oromia regions, and Eritrea and Djibouti. The region has a total area of 95,242 km^2 and according to the CSA (2008) a total population of 1.5 million.The CSA forecast, the population of the region to reach 1.7 million in 2015. The region is characterized by low rainfall of less than 300 mm (53% of the region) and average temperature exceeding 27.5 ^{o}C. The lowlands in the country support over 12% of the total human and 26% of the livestock population of the country (Coopock, 2004). The region is characterized by the general category of dryland and the people of Afar are practicing pastoral and agro-pastoral modes of life. Crop production in the region is practiced through irrigation; spate and river water abstraction.

The Amhara region (figure 1) is located in the north-western part of Ethiopia between 9°29' and 14°00' N latitude and 36° 20' and 40° 20' E longitude (Figure 1). It covers an area of about 157,121 km^2, with 11 administrative zones, a total of 113 woredas and 3,216 kebeles.The region has three major geographical zones, highlands (2,300 m above sea level), semi-highlands (1,500 to 2,300 m above sea level) and lowlands (1,500 m above sea level). The region is mainly characterized by undulating topography. The elevation ranges from 486 m to 4540 m above sea level with a mean value of 1878 m and standard deviation of 699 m. Amhara's biggest rivers include inter alia, Abay (the Blue Nile), Belese, Tekezie, Anghereb, Athbara, Mile, KessemandJema. Tana, the biggest lake in Ethiopia and the third largest in Africa, is located at the heart of the region. It has an area of 3,620 km^2.

Benishangul-Gumuz regional is one of the nine regional states established in 1994 by the new constitution of Ethiopia that created a federal system of governance. The region has international boundary with the Sudan in the west and is bordered by the Amhara region in the north and northeast, Oromiya in the southeast and

Gambellain the south (Figure 1). The regional capital, Asossa is located at a distance of 687 km west of Addis Ababa.

Oromia region has around 1.7 million ha potential irrigable land. However, only 14% of the potential land has been developed in the region. The rainfall in the region is bimodal and the annual rainfall ranges from 400 mm in the lowlands to 2,400 mm in the highlands. The region is predominantly an agrarian economy, with rain fed farming, flood-based farming and small scale irrigation providing livelihoods for 85% of the population (Haile et al., 2013).

The Southern Nations, Nationalities and People's Region (SNNPR) is located in the Southernand South-Western part of Ethiopia (Figure 1). It is bordered with Kenya, the Sudan, Gambella and Oromiyaregion.The total area of the region estimated to be 110,931.9 km² which is 10% of the county and inhabited by a population size of about 15,760,743 (1999 E.C.), accounting nearly 20% of the total population of the country. The region is a multination which consists of about 56 ethnic groups with their own distinct geographical location, language, cultures, and social identities living together.

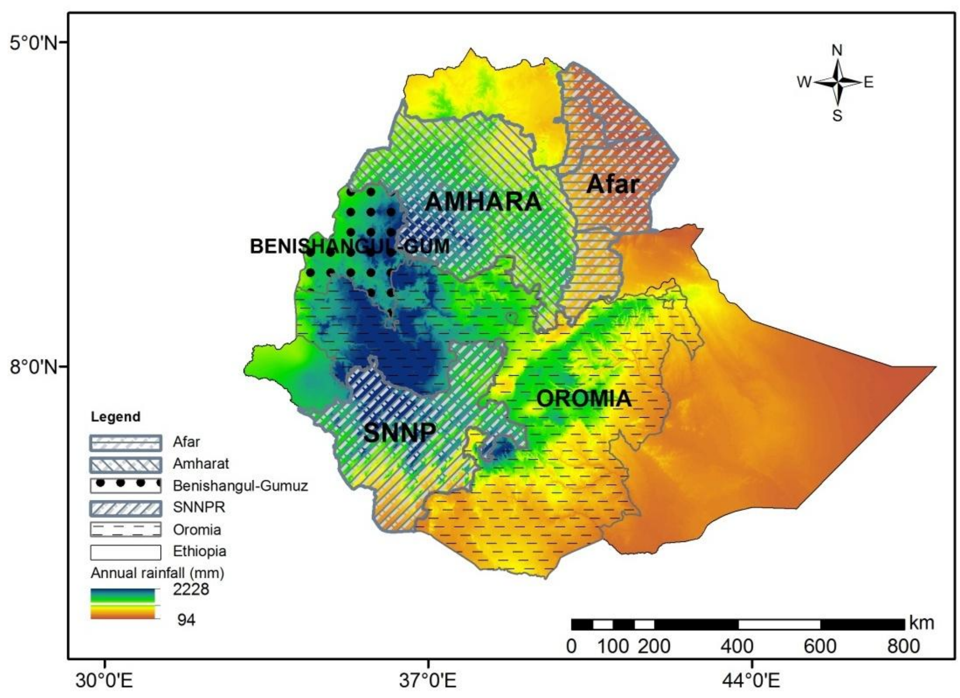
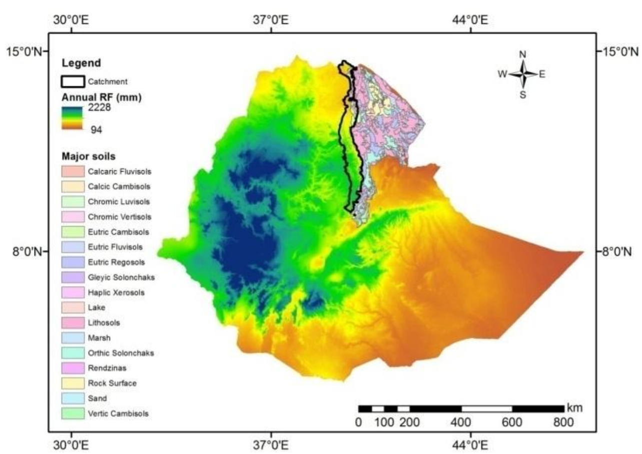


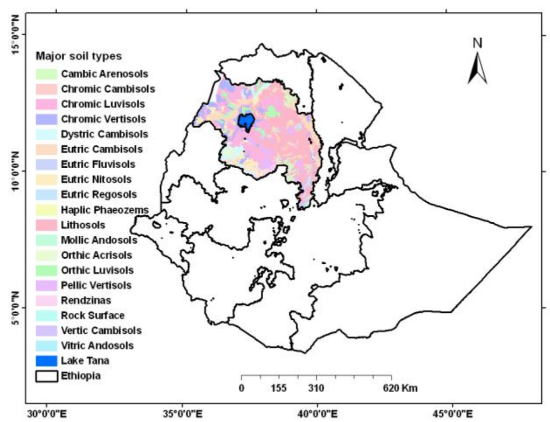
Figure 1: Location of the study area

Soil

The major soil types in Afar the study areaincludesCambisols, Fluvisols and Lithosols (Figure 2).The major soil types in the Amhara region include Arenosols, Cambisols, Luvisols, Vertisols, Fluvisols, Nitosols, Regosols, Lithosols, Andosols and Archisols. The major soil types in the region include Cambisols, Arenosols, Luvisols, Vertisols, Fluvisols, Nitosols, Regosols, Lithosols, Andosols and Archisols (Figure 2).

There are different soil types in SNNP Region, the dominate soil types in the area are, Chromic cambisols which is mostly found in the western part of the region. The second dominate type of the soil which is fond scattered in most of the region is chromic vertisols, Chromic luvisols is also available in the region in ample conations. Though other types of soils are found in small portion the three above mentioned soils are dominantly found both in the height land as well as in the lowland of the region which are very favorable for agricultural activities (Figure 2).





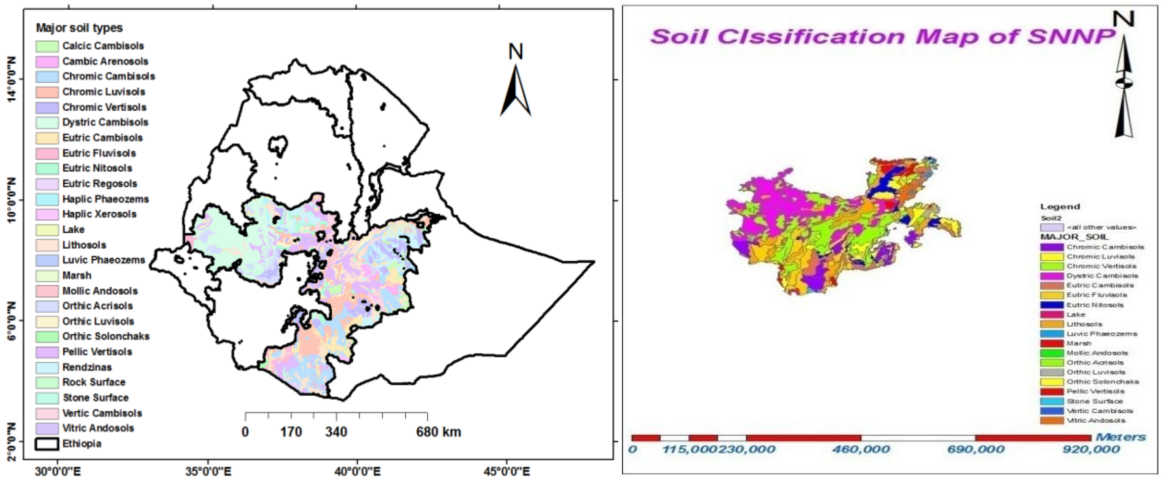


Figure 2: Major soils in Afar, Amhara, Benishangul-Gumuz and SNNP

Land use land cover

The major land use in Afarincludesshrub land, bareland, grassland and cultivation (Figure 3). The major land use/cover types in the Amhara region are natural forest, bare land, cultivation, grass land, plantation, shrub land, urban, wet land, wood land, and water body. The agro-ecology of the Benishangul-Gumuzregion is conducive for growing different types of food and cash crops. Sorghum, millet and maize (covering over 70% of the cultivated land) are the most dominant food crops grown in the region followed by finger millet, rice and teff. Oilseeds like sesame, Niger seed and sunflower are grown widely. In addition, pulses, vegetables, fruits, cotton, ginger and fiber crops are grown. Of these, the most important potential cash crops are sesame, cotton, mango and groundnut. Moreover some farmers grow coffee for local consumption and as a source of cash. The major land use/cover types in the region are natural bare land, cultivation, grass land, natural forest, plantation, shrub land, urban, wet land, wood land, and water body (Figure 4). The main land use in SNNP is shrub land, bare land, grassland and cultivation.

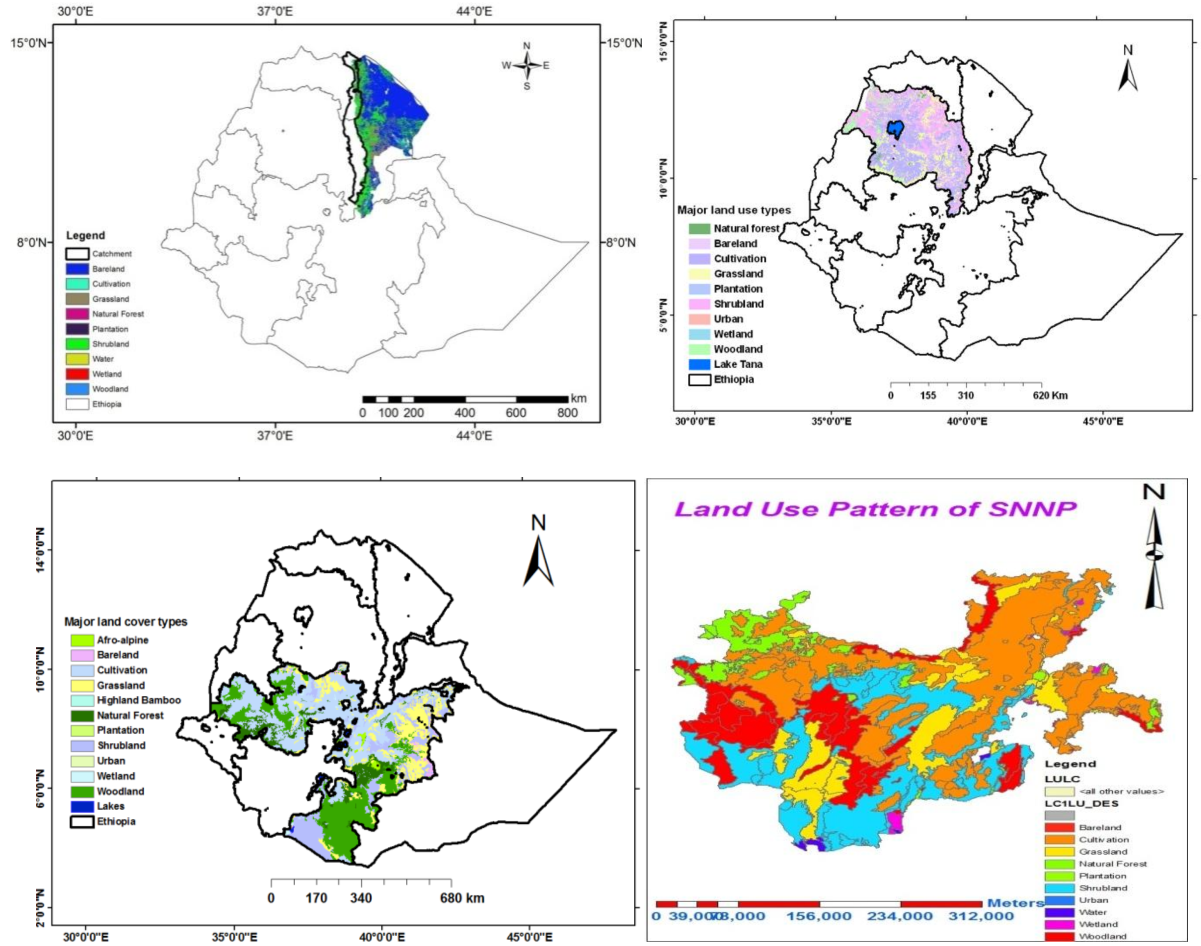


Figure 3: Major land use in Afar, Amhara, Oromiaand SPPN regions

Topography

The Afar area is characterized with flat with more than 51% is below 5%. The Amhara region has three major geographical zones, highlands (2,300 m above sea level), semi-highlands (1,500 to 2,300 m above sea level) and lowlands (1,500 m above sea level). The region is mainly characterized by undulating topography. The elevation ranges from 486 m to 4540 m above sea level with a mean value of 1878 m and standard deviation of 699 m. Amhara's biggest rivers include inter alia, Abay (the Blue Nile), Belese, Tekezie, Anghereb, Athbara, Mile, KessemandJema. Tana, the biggest lake in Ethiopia and the third largest in Africa, is located at the heart of the region. It has an area of 3,620 km^2(Figure 4).

The Benishangul-Gumuz region has a total area of approximately 50,380 km^2 with altitude ranging from 580 to 2,731 meters above sea level (masl). Agro-ecologically, it is divided into Kolla about 75% (lowlands below 1500 masl), WoinaDega about 24% (midland between 1,500-2,500 masl) and Dega about 1% (highland above 2,500 masl). Annual rainfall varies from 800 to 2000 mm (BGR, 2006). The temperature reaches a daily maximum of 20°C to 25°C in the rainy season and rises to 35°C to 40°C in the dry season. The hottest period is from February to April. The minimum daily temperatures range from 12°C to 20°C, depending on season and altitude (BGR, 2006).

The Benishangul-Gumuzregion is endowed withlarge water resources potential, both surface and ground water, which is distributed over the area. As the region lies in Abbay and partly in Baro-Akobo river system.Therefore the region's surface water resource may further be grouped in to 5 sub-basins, namely Didessa. Baro ,Dabus ,Beles and main Abbay, in to which the whole surface flow is drained. Except for the smaller tributaries ,all the main rivers originate from the highlands of neighboring ,mainly Oromia and Amhara. Recent studies carried out on the Abbay and Baro-Akobo rivers basins have revealed the suitability of these major rivers namely Beles, Dabus, Dura, Lugo and Bar for large and medium scale irrigation development.The SNNP region is characterized by flat with more than 59% is below 5%.

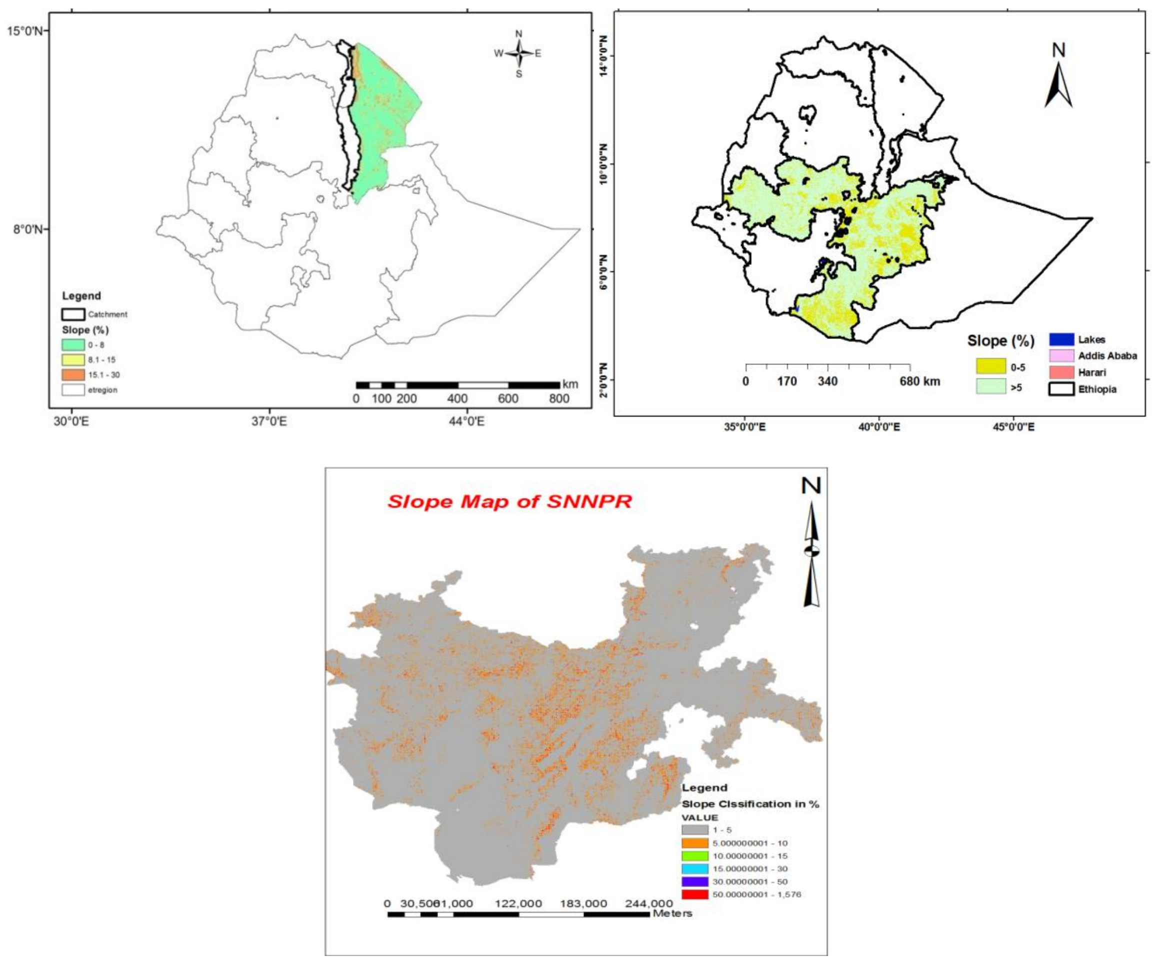


Figure 4:Topographical slope (%) at Afar, Oromia and SNNP Region

2.2 Methods

The potential irrigable area suitable for spate is selected by considering the rainfall, topography, soil, and land use land cover.Monthly rainfall data was obtained from world climate (www.worldclimate.org) at a spatial resolution of 1.0 km. The topography was analyzed based on the USGS 90.0 m DEM (earthexplorer.usgs.gov). Soil and land use map are adopted from FAO. The assessment for the Benishangul-Gumuz was made using secondary data and focus group discussion.

3.0 Results and Discussion

3.1 Afar Region

The Afar region has one of the highest spate irrigation potential and practices in Ethiopia as the runoff generated from the highlands of Tigray can suitably used in the immediate lowlands of Afar bordering Tigray (Figure 5). However, detail assessment of the potential of spate irrigation in Afar is not carried out to date. Though in several countries the area under spate irrigation is more or less stable, in the Horn of Africa it is expanding rapidly (IFAD, 2011). Moreover, different studies indicate contradicting figure on the extent of spate irrigation especially in Ethiopia. Few studies that indicate the potential of spate irrigation in Afar concentrate at Ab'ala and the assessment was mostly based on group discussion with farmers. Though the flush flood generated from the highlands of Tigray is intensively used in the immediate low lands of Afar, the potential of spate irrigation should be exploited further. The catchment for the surface runoff is considered the eastern escarpment part. This catchment produces runoff that is used for spate irrigation in Tigray and Afar.

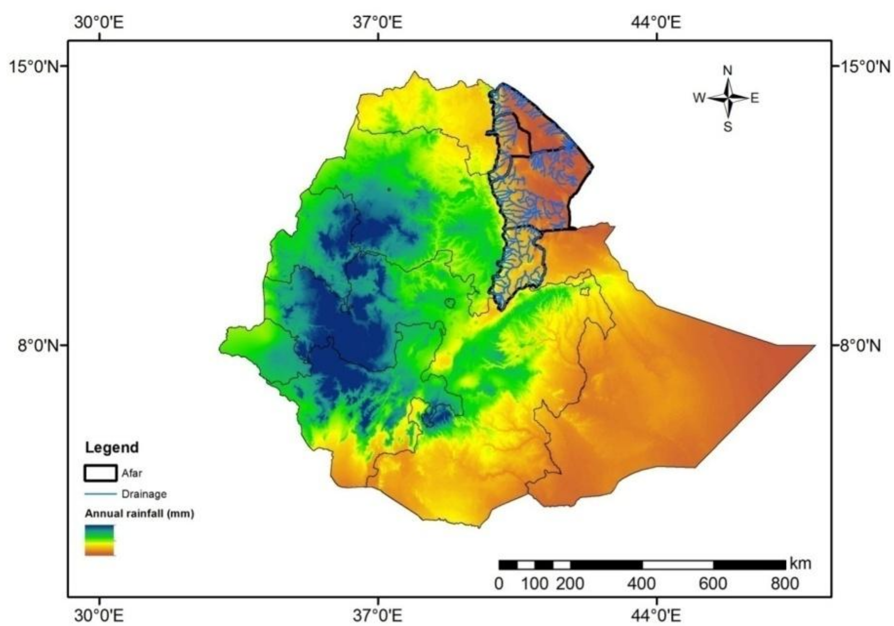


Figure 5: Afar region

Flood potential

The mean annual rainfall and the flush flood contributing catchment to Afar region is shown in Figure 6.

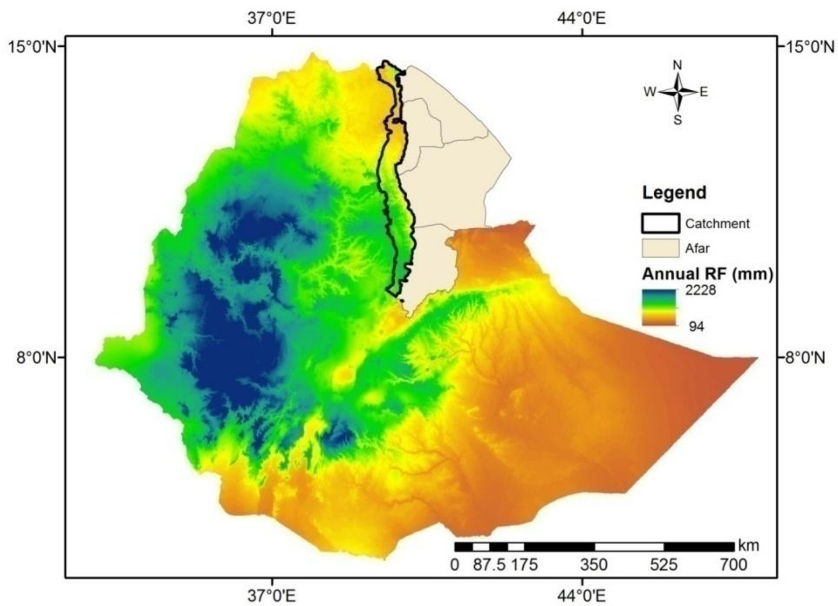


Figure 6: The highland part of Denakil and Awash that contributeflush floodto Afar.

The area of the catchment area in the highlands part of the Denakil and Awash river basins that drains to Afar is around 23,986 km^2.The flush flood expected from Afar itself for spate irrigation is considered to be negligible. The mean annual rainfall (RF) in this catchment is close to 831.8 mm. Assuming an irrigation requirement of 30,000 m^3/ha, the flush flood can irrigate area close to 133,010 ha. In Tigray, especially in the southern zone, the estimated area to be irrigated through flush flood is close to 25,000 ha. Hence the total available flush flood can irrigate an area close to 108,000 ha in Afar region.

3.2 Demand side

A further analysis of the slope, soil and the land use land cover reveals that the potential area that can be irrigated through spate is larger than the available water supply. The potential spate irrigable land based on soil, land use and slope is indicated below.

The total are of suitable for spate irrigation based on the soil classification is 44,604 km² (Figure 7). Soils selected to be suitable for spate irrigation include CalcaricFluvisols, Calcic Cambisols, Chromic Luvisols, EutricCambisols, EutricFluvisols and Lithosols.

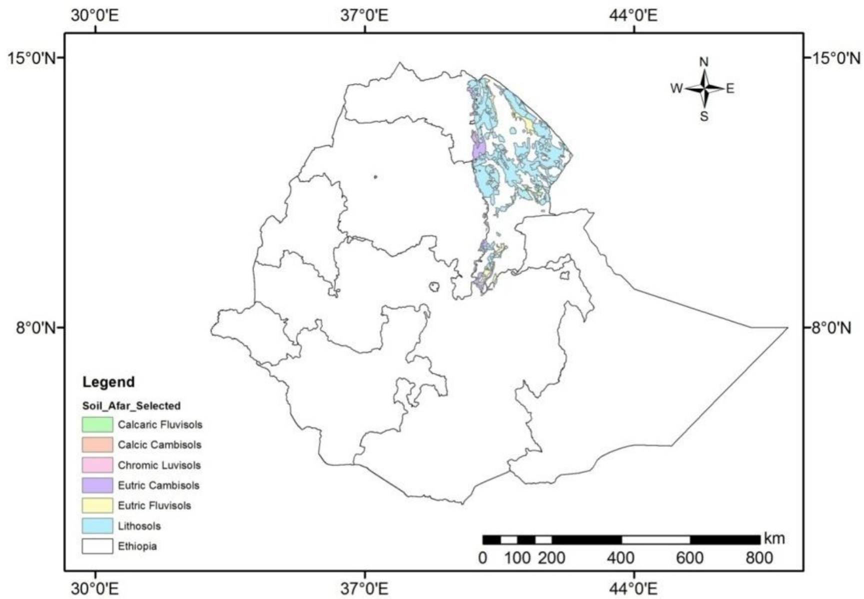


Figure 7: Suitable soil for spate irrigation

Based on the land use land cover, the area suitable for spate irrigation is 56,888 km² (Figure 8). The land use considered suitable consists cultivation, bare and grass land.

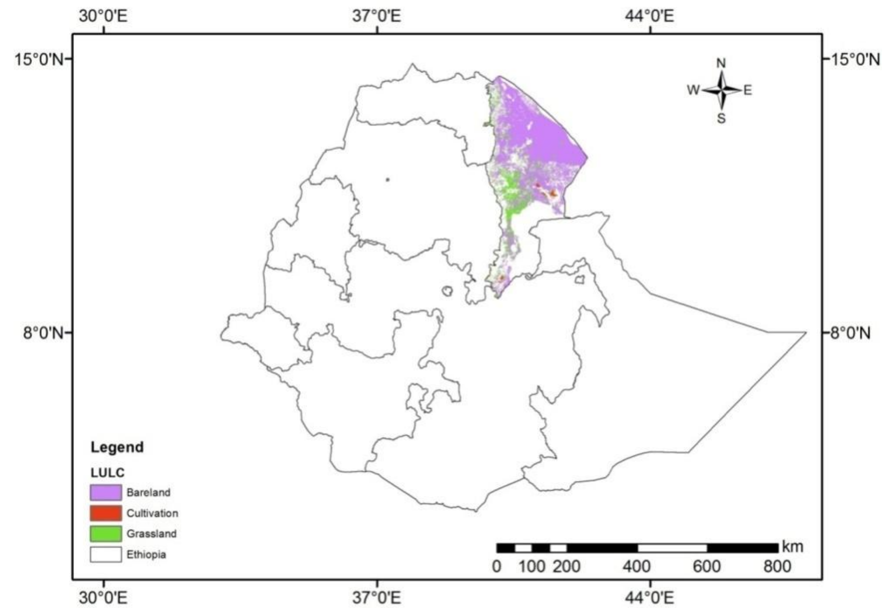


Figure 8: Land use land cover suitable for spate irrigation

Slope suitable for spate irrigation was found to be 48,674 km² (Figure 8). The slope class considered is from 1-5% (Figure 9).

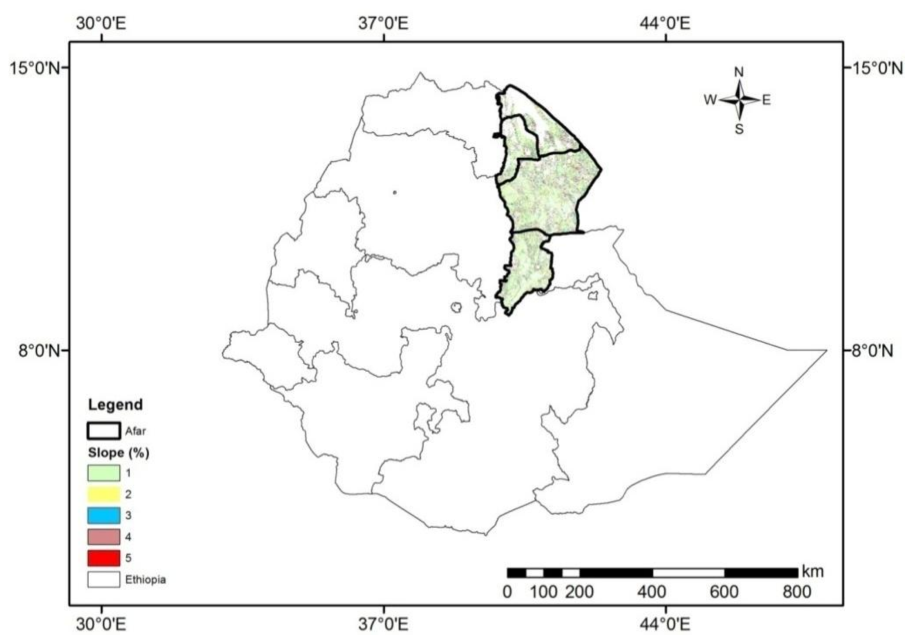


Figure 9: Slope class suitable for spate irrigation

By combining all those results, he potential area that is suitable for spate irrigation is found to be close to 1.3 million ha (Figure 10).

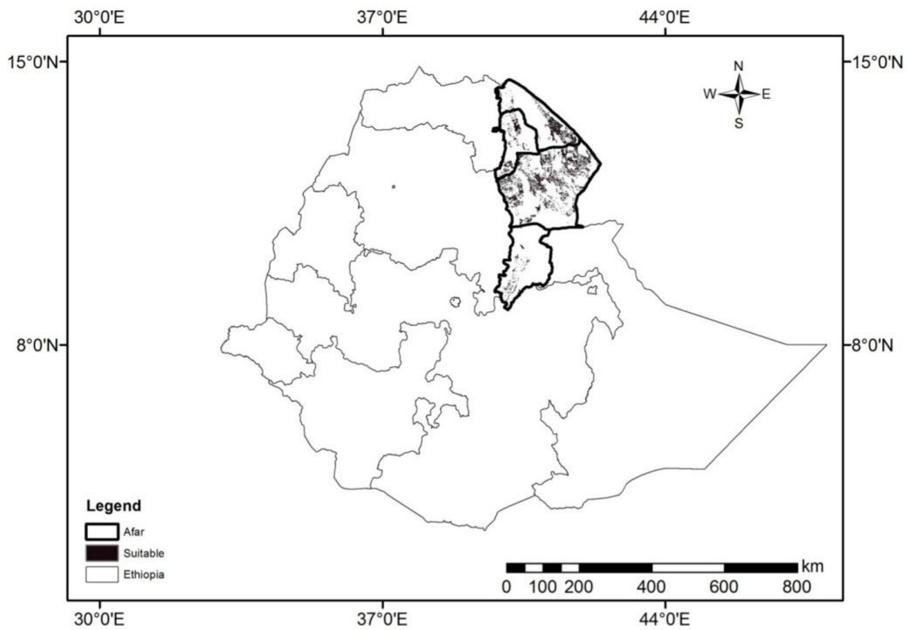


Figure 10: Suitable area for spate irrigation; by combining the land use, soil and slope

3.2 Amhara Region

Amhara region of Ethiopia has more than 700,000 ha of potentially irrigable land. Despite this huge potential of irrigable land only 90,000 ha of land or about 12 % of the irrigable land is currently under irrigation (Wondimkun and Tefera, 2006). Besides, the region is also believed to have a good potential for spate irrigation (Haile et al., 2013). However, spate irrigation practice is quite limited to few areas in the north eastern part of the region. According to Haile et al. (2013), some of the existing spate irrigation practices in the region are described as follows:

Gobu spate irrigation scheme, also referred to by the local community as “Adina Melie”, which means “lifesaving canal”, is administratively located within the Amhara region, north Wello zone, Raya Kobo Woreda along the border with Tigray region. Gobu had two schemes that were traditionally used for many years by the local community as the major sources of livelihoods. The spate flow was then diverted using bunds constructed from shrubs and earth materials. While one of the traditional schemes was completely damaged by large and uncontrollable floods and became out of use, the other was modernized in 2011. The modernization was initiated by the beneficiaries who found themselves unable to cope with the daunting task of managing the floods with their traditional structures. The design irrigation capacity is around 60 ha and this is sufficiently irrigated in good rainfall seasons.

Alewuha river diversion is situated 15 km N of Weldia town in Amhara region. The modern diversion weir constructed of concrete in 1995 has two scour sluices. The length of main canals reaches up to 4 km. The livelihoods of the area mainly depend on agriculture and rearing animals. The river is used to support crop production with some kind of modern and traditional irrigation systems. Around 178 farmers are benefiting from the modern irrigation diversion system from the river while 118 farmers are irrigating using the traditional diversion system. These farmers have a cultivated land that ranges from 0.0625 ha up to a little more than 1 ha. Water is sufficient for the existing farms if the diversion and canal network of the scheme works properly. On the other hand, there is more potential land suitable for cultivation, which could demand more water to bring these unexploited lands under irrigation.

Golina river diversion is located in a small town called Golina (between Robit and Kobo) found in Amhara Regional State, which is 4 km before Kobo on the way to Mekele. A concrete diversion structure is constructed with the mind-set of perennial irrigation design (small canals with no sediment control and management structures). Consequently the weir and canals only divert the base flows irrigating a maximum of 400 ha (potential is estimated at 800 ha) while the medium nondestructive floods are completely unutilized.

In their report, Haile et al. (2013) indicated that in addition to the schemes described above, several other seasonal rivers such as Wuchale, Wurgesa, Mersa and Robit are potential areas for spate irrigation development. Further, Amhara region has several river systems with non-stony river beds and adjacent gently sloping cultivable areas where flood spreading weirs could be viable options. These show efforts should be made to make use of these water resources by putting in place appropriate infrastructure and management system. However, to date the spatial extent of the potential spate irrigation areas in the region is not well addressed. Identifying the potential and promising areas for spate irrigation in the region helps farmers irrigate more area as well as improve their productivity. This study uses several multi-scale secondary data including soil, land use/cover, rainfall and topography (slope) in a GIS environment to identify promising areas for spate irrigation.

Slope map of the region was produced using the 3D-Analysis tools (surface analysis) of ArcGIS and the DEM data. The slope map was then reclassified in to two classes: Class I - 0-5% (suitable for spate irrigation) and Class II - >5% (not suitable for spate irrigation). Slope suitable for spate irrigation was found to be around 3,137,224 ha (Figure 11).

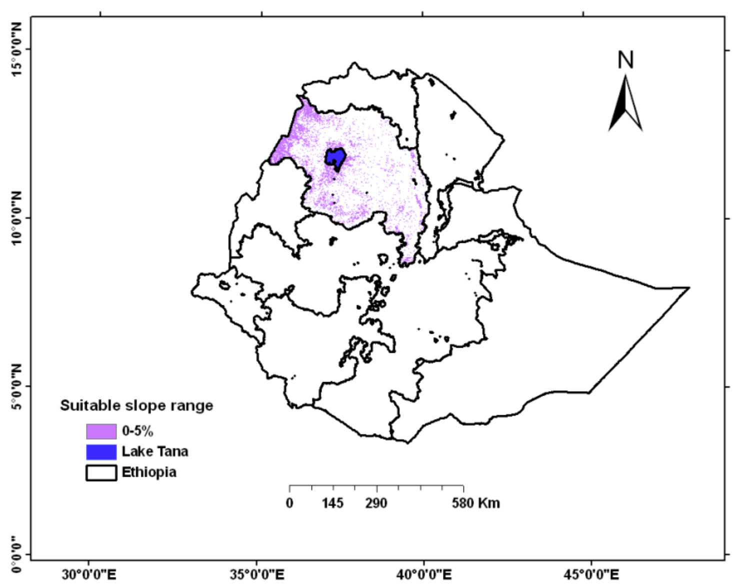


Figure 11: Slope class suitable for spate irrigation in Amhara region

Suitable soil

From the major soil types which are found in the region, soils which are not vertisol in nature are selected as suitable for spate irrigation (since vertisols have low infiltration and hence may lead to ponding of water). Based on the soil map adopted from FAO, the area considered suitable for spate irrigation in the region is around 12,601,264 ha (Figure 12).

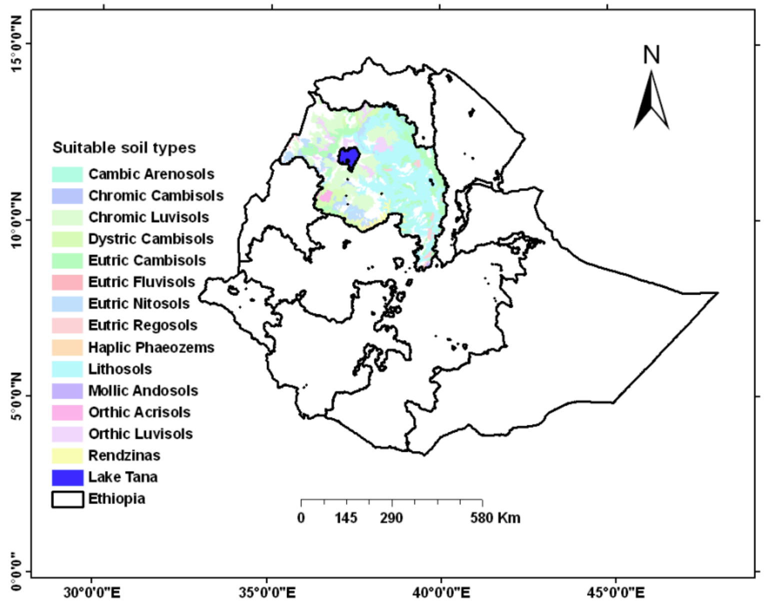


Figure 12: Soil types suitable for spate irrigation.

Suitable land use/cover

From the major land use/cover types in the region, cultivation, grass land and bare land were selected as suitable for spate irrigation. Based on the selected land use/cover types, the area considered suitable for spate irrigation was around 9,781,280 ha (Figure 13).

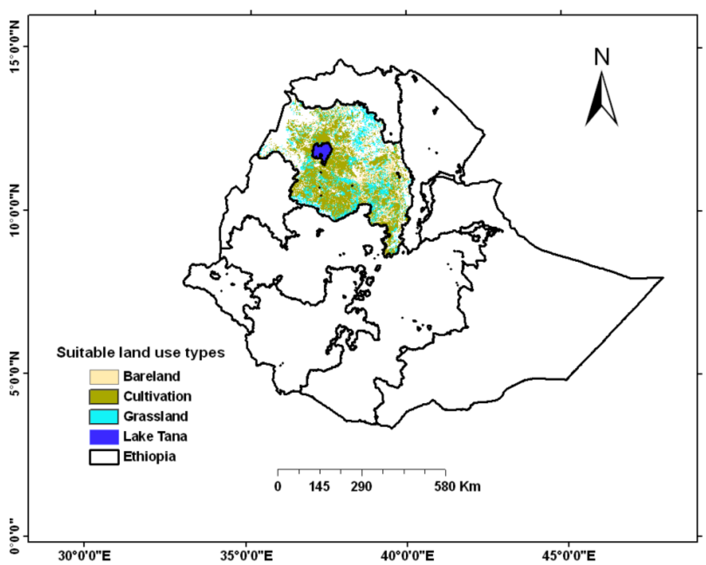


Figure 13: Land use/cover suitable for spate irrigation in Amhara region.

Potential area for spate irrigation

Once the suitable areas based on slope, soil and land use/cover were identified, overlay analysis (using raster calculator in ArcGIS) was done to produce a map layer which showed the suitable areas for spate irrigation based on the combined criteria. The result showed the areas which met the criteria set for slope, soil and land use/cover was around 1,079,588 ha (Figure 14).

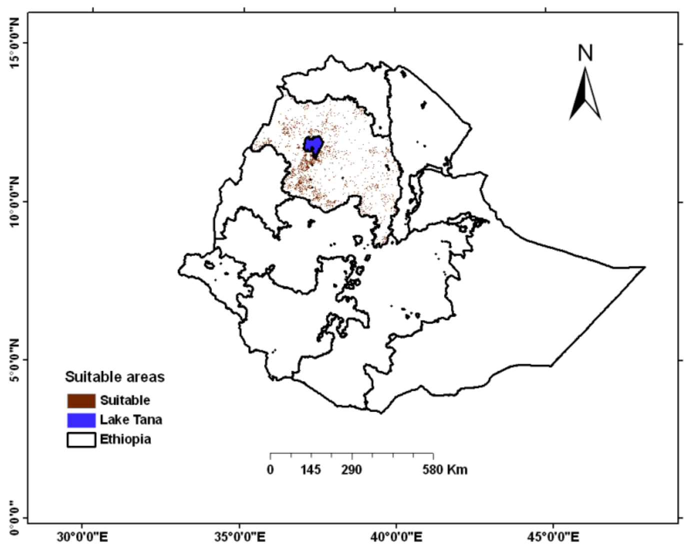


Figure 14: Suitable areas for spate irrigation in Amhara region.

3.3Benishangul-Gumuz Region

In the Benishangul-Gumuz Regional State the practice of spate irrigation is not totally practiced. However, as per the discussion with the regional head of water bureau and irrigation expert in the bureau indicates that at Guba, Sherkole, Kumruk, Bambasy, Tongo, and keshmando area (Asossawereda) weredas have the potential how much not yet studied and by identifying moisture deficit area that have a mean annual rainfall lower than350mm ,the region has more than 99,300 ha spate irrigation potential ,that is 75,00ha in Guba ,18,000 in Sherkole and 6,300 in Kumruk ,the other places mean annual rainfall is more than 350mm,but it needs intensive study on it . Therefore, to gain enough benefit from this irrigation system, extensive work has to be done for its contribution to achieve the irrigation development efforts to the region and the country set on the growth and development plan at large.

Taking into account the surface water potential of the region, three irrigation potential on Beles and Dabus rivers for large scale development to irrigate about 119,820 ha land and three others schemes on Bar, Lugo and Dura rivers for medium scales development and, irrigating a total area of about 2,357 ha have been proposed in the master plan study and the small scale irrigation potential estimated to be more than 1615 ha,which are all located in the territory of the region.

Not much is known regarding the ground water potential of the region, except a general information indicating its existence in a huge quantity and good quality .the utilization of this resource has been limited to only rural and urban water supply for human consumption .A number of hand dug wells and a few deep wells have been dug to extract the ground water resource in many areas of the region. The groundwater level can be reached at a shallow depth (not exceeding in 10m) as observed around Assosa and other areas.

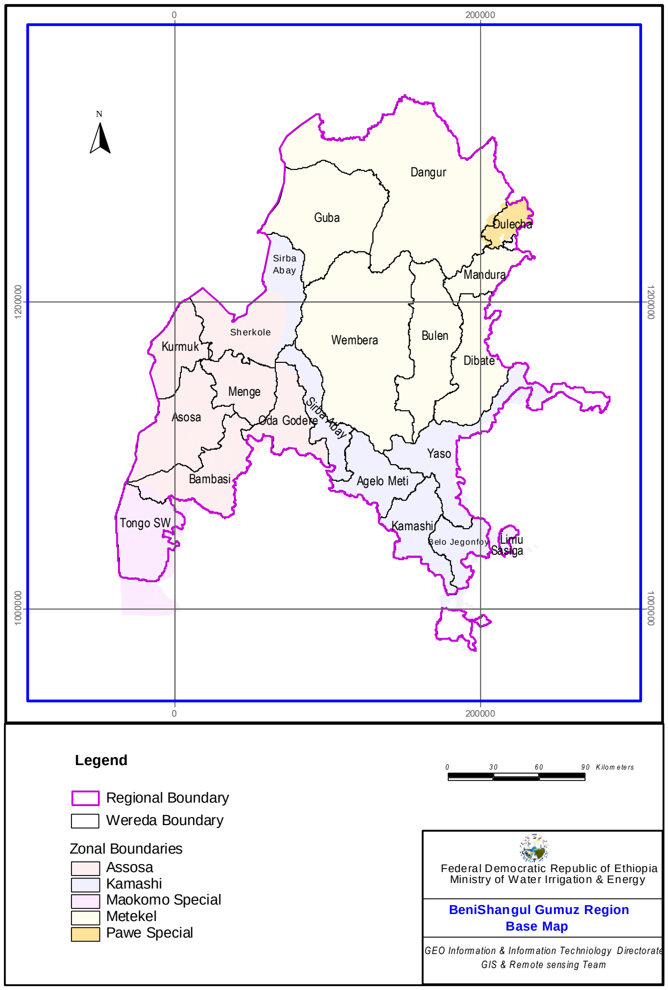


Figure 15: Administrative boundary of Benishangul-Gumuz Region

3.4Oromia Region

Spate irrigation is traditionally known and experienced in especially in lowland areas of Oromia. Traditionally termed as Galchaa direct meaning is to collect and transport flood to the command area. In the region modern spate irrigation is started in 1998 in east and west Harerge zone. The first spate irrigation in Oromia mainly are: IjaGalmawaqo (Fedis – East Harargee); IjaMalabe (Fedis- East Harargee); Bililo (Mi'eso- West Harargee); Hargetii (Mi'eso – West Harargee). Lowland areas of Oromia, especially those in Hararge, East Shawa, Arsi, Bale, Borena and Guji zones are known to have ample potential area for spate irrigation, small, medium and large scale conventional irrigation development. In areas where spate irrigation is already practiced, the water is used for domestic purposes and supplementary irrigation. From agriculture point of view it has multiple benefits: moisture increase on the farm land, transports fertile soil, yield increase, etc.

Suitable slope

Slope map of the region was produced using the 3D-Analysis tools (surface analysis) of ArcGIS and the DEM data. The slope map was then reclassified in to two classes: Class I - 0-5% (suitable for spate irrigation) and Class II - >5% (not suitable for spate irrigation). Slope suitable for spate irrigation was found to be around 8,480,821 ha (Figure 16).

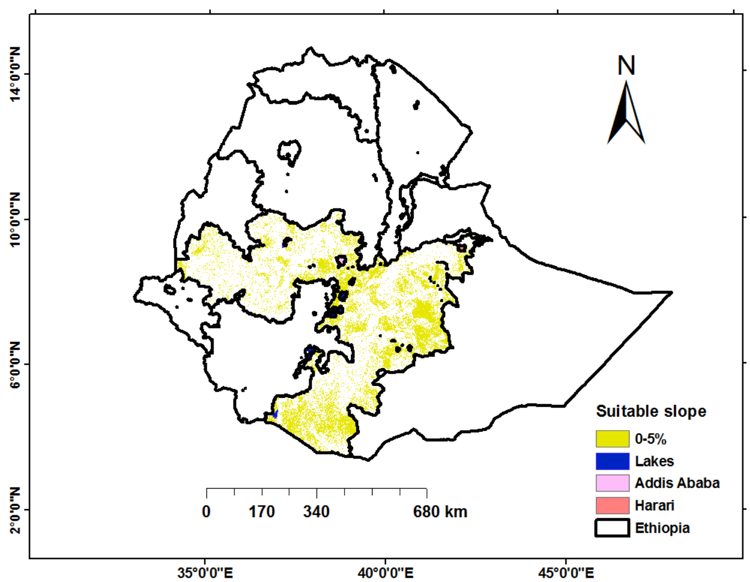


Figure 16:Slope class suitable for spate irrigation

Suitable soil

From the major soil types which are found in the region, soils which are not vertisol in nature are selected as suitable for spate irrigation (since vertisols have low infiltration and hence may lead to ponding of water). Based on the soil map adopted from FAO, the area considered suitable for spate irrigation in the region is around 23,562,530 ha (Figure 17).

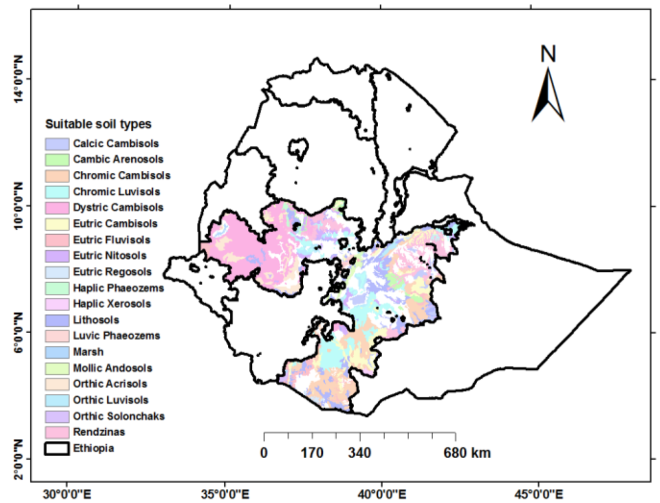


Figure 17: Soil types suitable for spate irrigation.

Suitable land use/cover

From the major land use/cover types in the region, cultivation, grass land, wetland and bare land were selected as suitable for spate irrigation. Based on the selected land use/cover types, the area considered suitable for spate irrigation was around 15,710,376 ha (Figure 18).

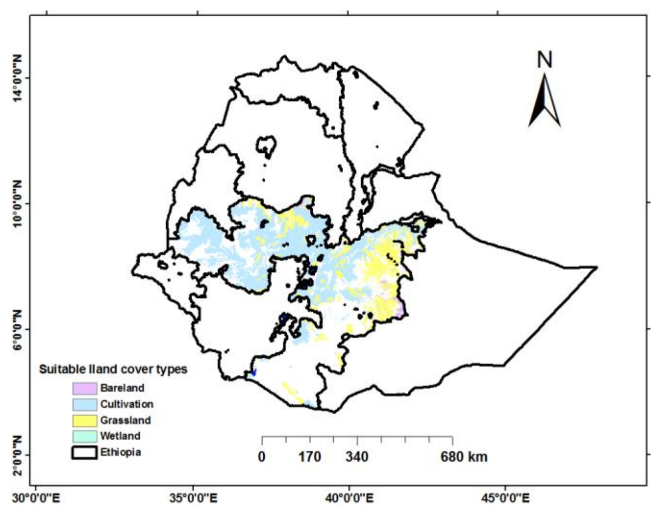


Figure 18: Land use/cover suitable for spate irrigation

Potential area for spate irrigation

Once the suitable areas based on slope, soil and land use/cover were identified, overlay analysis (using raster calculator in ArcGIS) was done to produce a map layer which showed the suitable areas for spate irrigation based on the combined criteria. The result showed the areas which met the criteria set for slope, soil and land use/cover was around 2,557,172 ha (Figure 19).

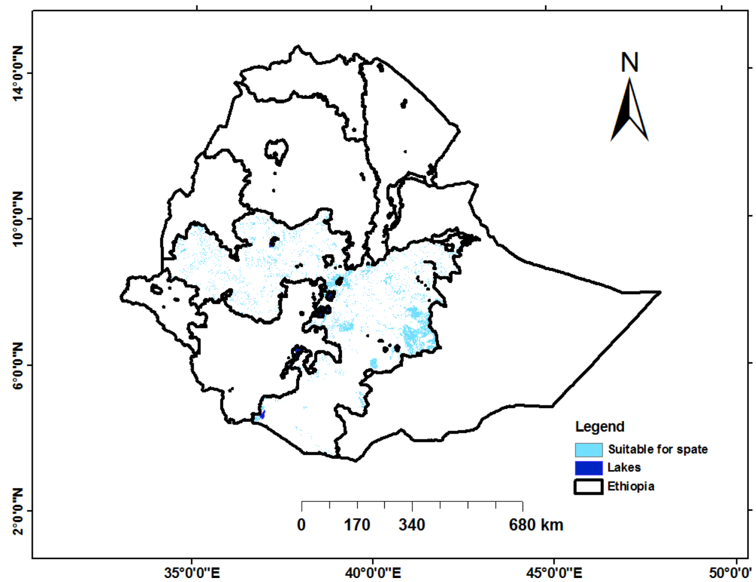


Figure 19: Suitable areas for spate irrigation

3.5The Southern Nations, Nationalities and People's (SNNPR) Region

The mean annual rainfall and the flush flood contributing catchment to SNNP Regional state is shown in Figure 15.

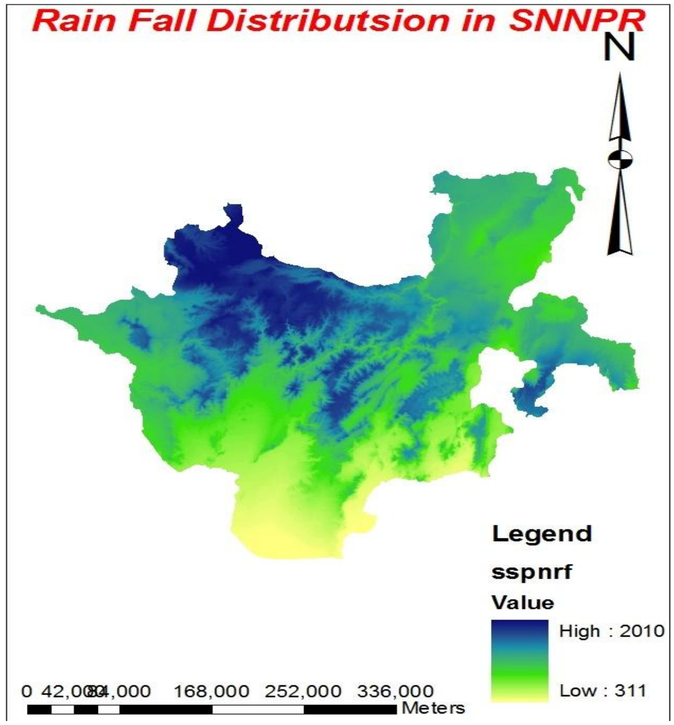


Figure 20: Rainfall distribution in SNNPR

The area of the catchment area in the highlands part of the region of which drains to lowland of SNNP region is around 55,465,95 km^2. The mean annual rainfall (RF) in this catchment is close to 1160 mm. if it is considered that the runoff coefficient to the region is as that of 0.3, the total runoff generated from the catchments will be 19.3Bm^3. If again we considered or assuming an irrigation requirement of 25,000 m^3/ha, the flush flood can irrigate area close to 772,419 ha. Therefore, at this level of assessment study a nearly 772,419 ha of land is identified to be irrigated using spate irrigation in the SNNPR.

4.0 Conclusions and recommendations

4.1 Conclusions

This study aimed at assessing the potential areas for spate irrigation in Afar, Amhara and SNNP regions of Ethiopia by making use of multi-scale secondary data.

Afar region is one of the potential regions where spate irrigation is practiced most. However, the potential area is not well investigated and this study can be a starting point for future references.The study identified that the region has huge potential of irrigable area, close to 1.3 million ha. However, the major limiting factor for the spate irrigation is the availability of water. With this limiting factor, the total area that can be irrigated through spate is close to 108,000 ha.

In Amhara, based on the combined analysis of slope, soil and land use/cover, around 1,079,588 ha is considered as suitable for spate irrigation. However, the suitable areas are not well investigated and this study can be a starting point for future references. Further, the one of the major limiting factors for the spate irrigation is the availability of water. But, in this study detailed investigation of the flood that can be generated from watersheds into the low land areas was not done. As such, to further refine the suitable areas for spate irrigation detailed study need to be undertaken by considering availability of water as one limiting factor. In general, this can be a starting point to identify the potential irrigable areas of the region. But, detailed feasibility study is imperative on the suitable areas for spate irrigation and the possible interventions to be made.

In the Benishangul-GumuzRegional State the practice of spate irrigation is not totally practiced. However, based on the focus group discussion the region has more than 99,300 ha spate irrigation potential. However, this has to be verified further using remote sensing and GIS approaches.

In Oromia region, close to 2,557,172 ha of is considered as suitable for spate irrigation. However, the suitable areas are not well investigated and this study can be a starting point for future references. Further, the one of the major limiting factors for the spate irrigation is the availability of water. But, in this study detailed investigation of the flood that can be generated from watersheds into the low land areas was not done. As such, to further refine the suitable areas for spate irrigation detailed study need to be undertaken by considering availability of water as one limiting factor. In general, this can be a starting point to identify the potential irrigable areas of the region. But, detailed feasibility study is imperative on the suitable areas for spate irrigation and the possible interventions to be made.

SNNP region is one of the potential regions where spate irrigation is practiced most. The study identified that the region has huge potential of irrigable area, close to 4.3 million ha. However, the major limiting factor for the spate irrigation is the availability of water. With this limiting factor, the total area that can be irrigated through spate is close to 773,000 ha.

4.2 Recommendation

To maximize the benefit from irrigation, especially additional water sources like ground water should be explored. Through these water sources the potential of flood-based farming system can also be explored.

This study was conducted based on analysis of secondary data. Though, this can be a starting point to identify the potential irrigable area of the region, detail investigation should follow for ground data verification through field visit, discussion with stakeholders and field data sampling.

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