Article

Land degradation status and trends in Baro-Akobo river basin, Ethiopia

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Abstract
This review aims to illustrate the status and trends of land degradation in Baro-Akobo river basin of Ethiopia. Land degradation takes place in the forms of vegetation degradation, soil degradation and water degradation. To review the land degradation status and trends in the basin, a systematic desk review has been made. It discussed the vegetation degradation status and trends, soil degradation status and trends and water degradation status and trends of the basin. In Ethiopia, the dependence of the rapid population growth on unmannerly types of existence agriculture and natural resources use are the key reason for the those forms of land degradation. The land degradation in Baro-Akobo basin is caused maily by the massive resettlement, commercial farming expansion and over utilization of resources. Therefore, this review is important to understand the status and trends of land degradation in Baro-Akobo river basin for reversing the deterioration of land resources in the basin.

Keywords land degradation; river basin; trends; Ethiopia.

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1 Introduction

Land is the primary means of production used to generate a livelihood for most of developing countries. As its highest importance, its degradation also highest (Negasa, 2022). Land degradation has become a serious problem in developing countries in general and in Ethiopia in particular; it is one of the major challenges to agricultural development and food security of the country (Kiflemariam, 2008).

Land degradation takes place in the forms of vegetation degradation, soil degradation and water degradation (Temesgen, 2015). In Ethiopia, the dependence of the rapid population growth on unmannerly types of existence agriculture and natural resources use are the key reason for the those land degradation forms (forest, soil and water degradations) (Gebre et al., 2020).

In Baro-Akobo river basin, anthropogenic pressures such as massive resettlement, expansion of the commercial farming system, population density, mismanagement of cultivated and continuous cultivation, and natural factors such as steep terrain and ragged topography attributed to land degradation, or natural resources degradation (vegetation degradation, soil degradation and water deterioration) (Taye et al., 2016; Negasa, 2022). As a result of the land degradation, the production and productivity of the area deteriorated year after year and living standard of the population has become worsening year after year (Negasa, 2022).

Therefore, this review is important to understand the status and trends of land degradation in Baro-Akobo river basin for reversing the deterioration of land resources in the basin.

2 Methodology

2.1 Study area description

Baro-Akobo River basin is partially part of the south western Ethiopian Plateau with a peak elevation of 3240 m a.s.l (Fig. 1). Towards west, the rolling and hilly morphology abruptly changes into dominant long chain of sharp escarpments and lowland plain with lowest elevation of 395 m a.s.l. The basin is the second smallest river basin with an area of 75,912 km^2 (6.9% of the country) among the eight river basin of the country.

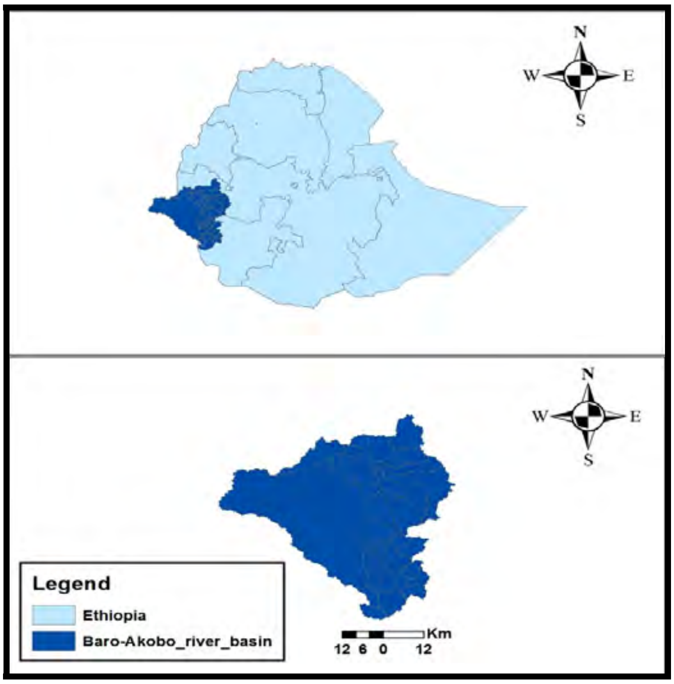


Fig. 1 Map of the study area.

2.2 Data collection methods

To review the land degradation status and trends in the basin, a systematic desk review has been made on existing literatures of the sub-basins in Baro-Akobo basin (published and non-published articles). And, Baro-Akobo River Basin Integrated Development Master Plan by TAMS and ULG (1997) was used.

3 Land Degradation Status and Trends in Baro-Akobo River Basin

3.1 Vegetation covers status and trends

Understanding on vegetation cover status and trends are important for many planning and management, including river basin planning (Mundia and Aniya, 2006; Stoate et al., 2001). The dominant lands covers types in Baro-Akobo river basin are sparse and dense woodland (32.5%) followed by stocked and lightly to moderately stocked cultivation (25.3%), open and dense to close Montane broadleaf forest (16.8%) and grass cover with and without trees (14%). In the remaining parts of the basin open and dense to closed semi evergreen forest, perennial and seasonal swamp and open to dense shrub land constitute 4.7%, 3.4% and 2.8%, respectively (Taye et al., 2016).

Baro-Akobo river basin has been experiencing forest land conversion to agricultural and settlement land uses in the past decades (Woube, 1999) Sutcliffe (2009) reported that forest in Baro basin was deforested at the rate of 1.6% per year for the market and local purposes (Fig. 3). Alemayoh et al. (2018) also found that significant decrement of forest land use land cover changes were occurred due to anthropogenic activities in Geba watershed of the Baro basin between the year 1984 and 2010. Areas of dense mix high forest, lowland bamboo and riparian woodland was decreased by 19.25, 34.70 and 25.18%, respectively (Fig. 2).

Another study in upper Baro basin (areas include such as Ayra,Meti, Dambi Dollo, Bure, Alge, Gore, Masha and others) also stated that forest land and shrub land decreased after 1987–2017, with 3.41% and 4.65%, respectively (Tewodros et al., 2021). In the last 30 years, the study displays an increase in agriculture, bare land, urban, and shrub land, whereas the forest, grassland, water, and wetland were noted declined (Table 1). Agricultural land increased by 18.01% during the study period (Tewodros et al., 2021). A study conducted by Mekuria (2005), in two sub catchments (Shomba and Michity sub-catchments)of Baro- Akobo river basin also elaborated that the vegetation covers in Shomba and Michity sub-catchments (Kefa zone) of Baro-Akobo river basin have undergone significant alterations and transformations over the last 34 years (1967-2001).

In 1967, a large area of the Shomba sub-catchment was covered by natural forest (35%) and wooded grassland (30%). After ten years (1987), the wooded grassland and the natural forest dramatically declined to 8% and 21%, respectively. After three decades (in 2001), 75% of the sub-catchment was already converted to cultivated land and settlements, while only 19% remained under vegetation cover (natural forest 7%, wooded grassland 6% and grassland 6%) (Mekuria, 2005). Similarly in Michity sub-catchment, the natural forest cover was more than 62% in 1987. After 14 years (in 2001), it declined to 52%. While the wooded grassland area considerably dropped, cultivated land and settlements increased from 12% and 4% in 1987 to 23% and 11% in 2001, respectively (Mekuria, 2005) (Fig. 4). Such enlightened expansions in cultivated land and settlements are outward indicators of a continuous increase in population density. Population increase is generally the main human factor in vegetation cover change in Ethiopia (Gebre et al., 2020).

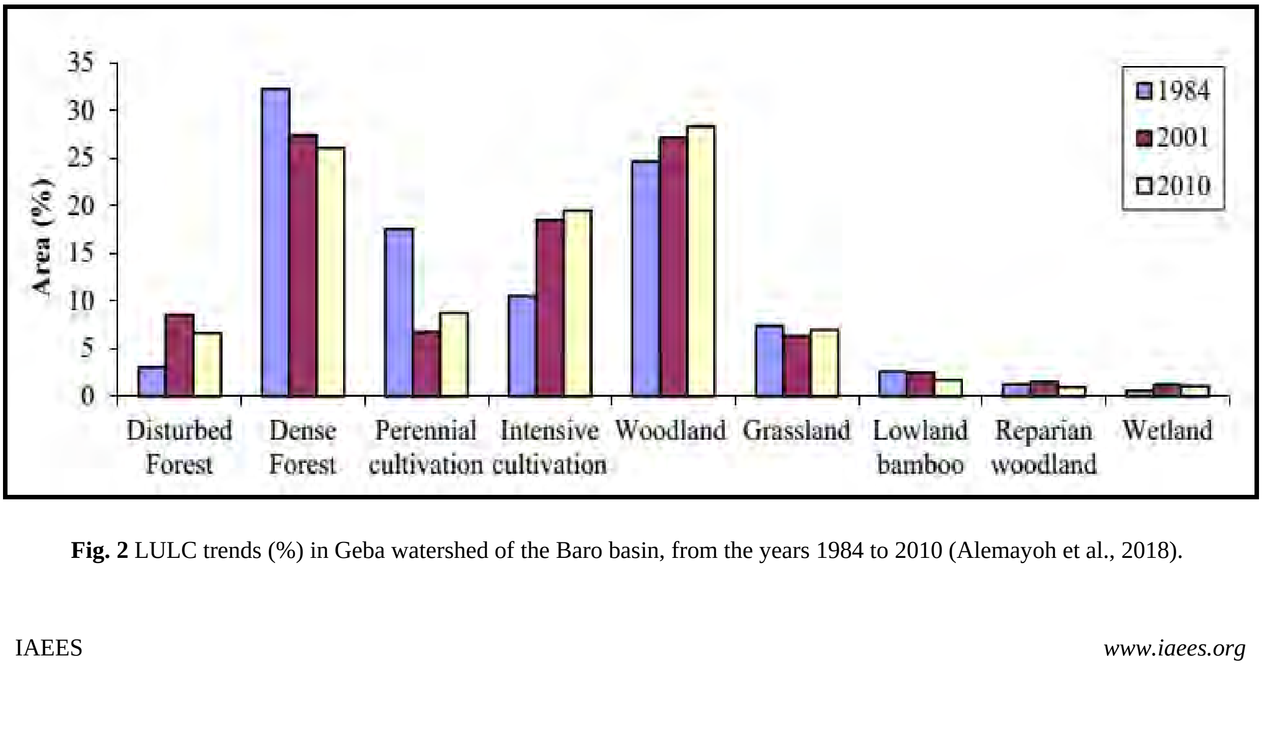


Fig. 2 LULC trends (%) in Geba watershed of the Baro basin, from the years 1984 to 2010 (Alemayoh et al., 2018).

Fig. 3 Deforestation in the Geba watershed of Baro basin (Alemayoh et al., 2018).

Table 1 Land use/ land cover trends (1987-2017) in Upper Baro–Akobo basin (Tewodros et al., 2021).

Land use class	1987		Spatial converge 2002		2017		2002–1987		Change between years 2017-2002		2017–1987	
	(km^2)	%	(km^2)	%	(km^2)	%	(km^2)	%	(km^2)	%	(km^2)	%
Grass land	4639.21	19.77	3272.15	13.95	969.34	4.13	−1367.05	–5.83	–2302.81	–9.82	–3669.87	–15.64
Agricultural	2065.92	8.81	3659.08	15.60	6290.56	26.81	1593.15	6.79	2631.48	11.22	4224.63	18.01
Bare land	92.81	0.40	166.24	0.71	217.43	0.93	73.43	0.31	51.19	0.22	124.62	0.53
Urban	471.30	2.01	2060.52	8.78	3638.16	15.51	1589.23	6.77	1577.64	6.72	3166.86	13.50
Woodland	2656.81	11.32	2812.80	11.99	2,447.74	10.43	155.98	0.66	–365.06	–1.56	–209.08	–0.89
Forestland	8619.97	36.74	7819.91	33.33	7323.35	31.21	–800.06	–3.41	-496.56	–2.12	–1296.62	–5.53
Shrub land	4635.94	19.76	3544.63	15.11	2393.95	10.20	–1091.31	–4.65	–1150.69	–4.90	–2241.99	–9.56

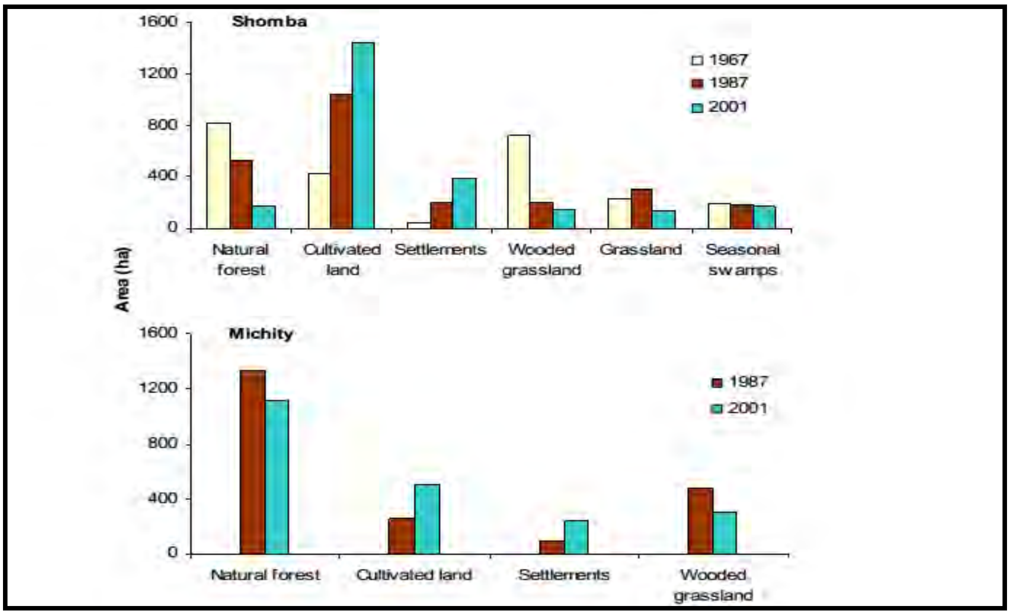


Fig. 4 Vegetation cover trends in Shomba andMinchity sub-catchments of Baro –Akobo river basin (Mekuria, 2005).

3.2 Soil degradation status and trends

According to the classification of FAO's nation-wide work (FAO, 1984), soils of the Baro-Akobo basin are dominantly Cambisols, Vertisols, Fluvisols and Acrisols, followed by small coverage of Nitisols and Lithosols (Fig. 5).

The highland area is predominantly covered by Dystric Cambisols. Lithosols are found very much localized within the highlands. The escarpment/the intermediate zone has predominantly Eutric Fluvisols followed by Orthic Acrisols. The lowland plain is mostly covered by Chromic Vertisols. Minor Eutric Fluvisols are found along the rivers banks. Conversion of these soil classes with SPAW Hydrology (Hydro lab, 2007) into texture soil class shows the soils of the basin to be 79.7% clay, 10.8% clay loam and 9.4% sandy clay (Taye et al., 2016).

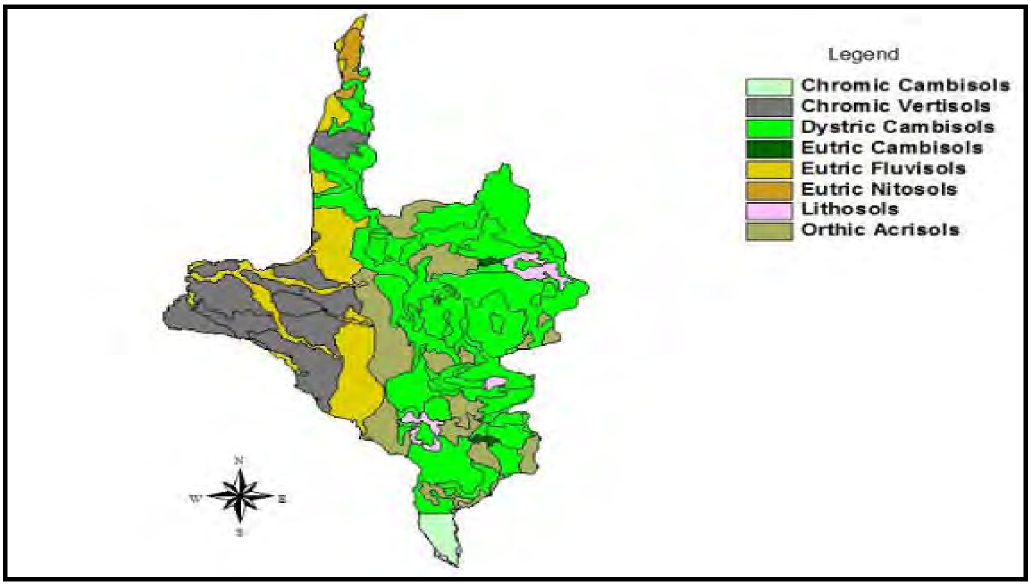


Fig. 5 Soil map of Baro-Akobo Basin (FAO, 1984).

Soil degradation(both soil erosion and quality deterioration) is one of the most severe problems affecting the agricultural sector in Ethiopia (Sonneveld, 2002). In Baro–Akobo basin there are different agro-industry companies to produce commercial farm products. Accordingly, soil erosion and soil quality deterioration, which are posing a threat to the environmental sustainability, are common (Beshir and Awdenegest, 2015).

According to Taye et al. (2016), the total annual soil loss in Baro-Akobo basin was found 107 million tons for the period 1973-2001. This value rose to 137 million tons and further to 140 million tons, for the period 1986 to 2001 and 2001 to 2014, respectively (Fig. 6). Nearly 95% of the increment happened during the period 1973 to 2001. The area, which is being intensively cultivated, is the most affected area.

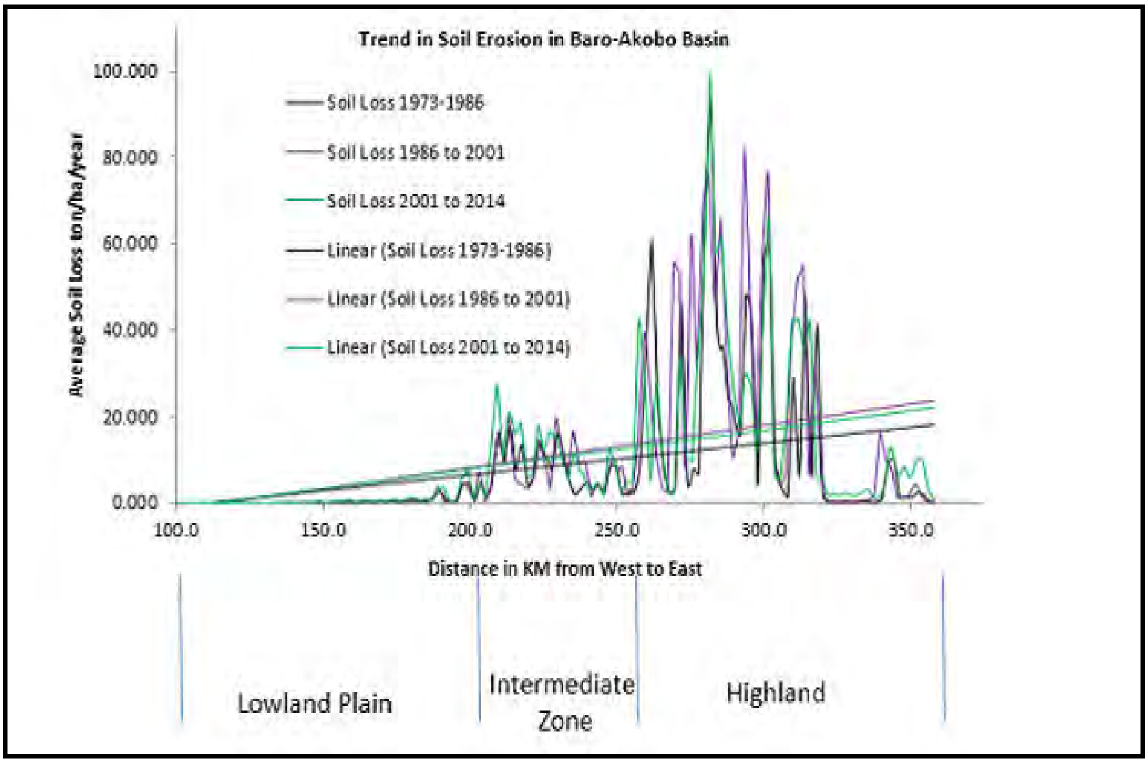


Fig. 6 Soil erosion trends (1973-2014) in Baro –Akobo Basin (Taye et al., 2016).

Annual soil loss estimation conducted by Beshir and Awdenegest (2015) in Jima zone (Sigmo, Gera and Setema districts) also found that, about 14.3% and 18.1% of the area fall in the very high erosion risk class (>50 t/ha/yr.) in 2001 and 2013, respectively; which indicates the severity of erosion in the area (Table 2). Mekuria (2005) also found that soil erosion range from 20 to 30 t/ ha/yr. in the introduced cereal crop-based system, whereas the rates in the traditional system range from 5 to 8 t/ ha/yr. in Kefa Zone of Baro–kobo river Basin.

Table 2 Soil erosion rates and severity classes in Jimma Zone (Sigmo, Gera and Setema districts) (Beshir and Awdenegest, 2015).

	Low		Moderate		High		Very high	
Districts	2001	2013	2001	2013	2001	2013	2001	2013
Sigmo	98.4	96.3	1.2	2.9	0.3	0.6	0.1	0.2
Gera	95.9	94.5	3.1	4.1	0.8	1.1	0.2	0.4
Setema	93.2	86.4	5.2	10.1	1	2.3	0.5	1.1

In Geba watershed, a sub-watershed of Baro river basin researchers such as Alemayoh et al. (2018) found that annual average soil loss rate as12.85, 14.38 and 14.89 t/ha/year in the years 1984, 2001 and 2010, respectively. The trend of soil erosion rate have shown significant increment from 1984 to 2010 which was found to be 21.2, 61.73, and 71.21%, respectively (Fig. 7).

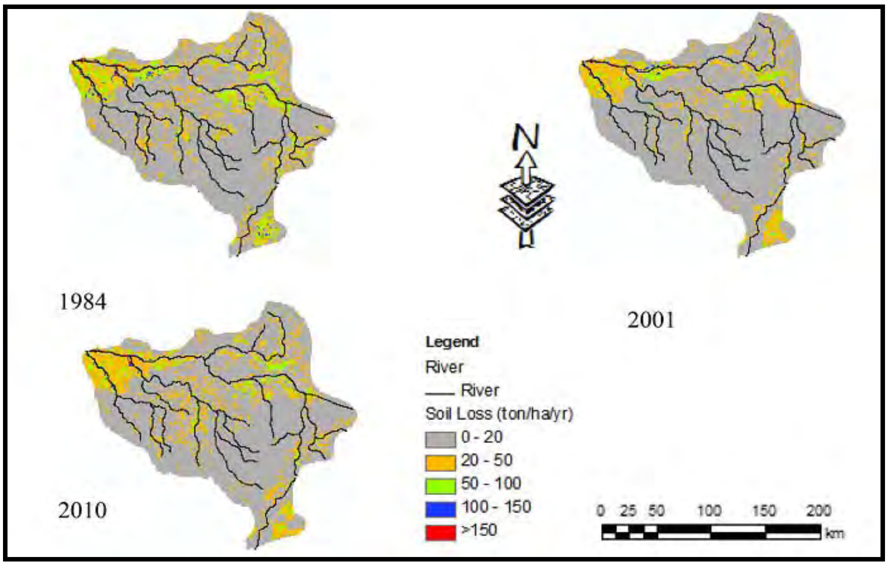


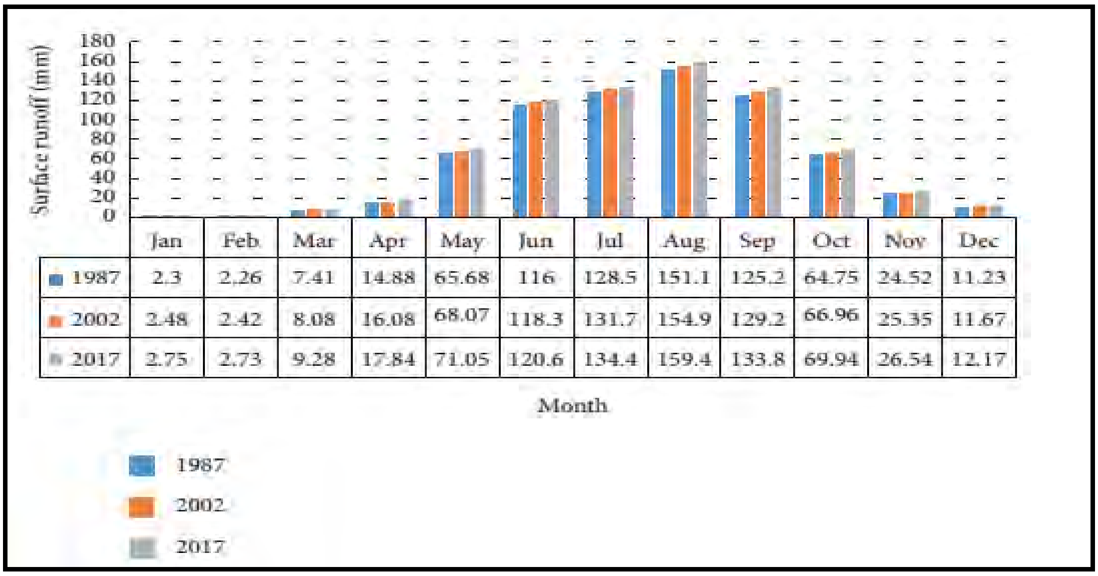
Fig. 7 Soil loss trends in Geba watershed of the Baro basin from the years 1984 to 2010 (Alemayoh et al., 2018).

3.3 Water degradation status and trends

Water degradation refers the declines of water quality and quantity (Temesgen, 2015). In Ethiopia, the high population pressure leads the water courses to dry up, reduced the volumes of surface water, depletion of aquifers and pollution (Gebre et al., 2020). Teklu (2016) stated that, the application of chemical fertilizers and insecticides by high population of Ethiopia lead surface and ground contamination.

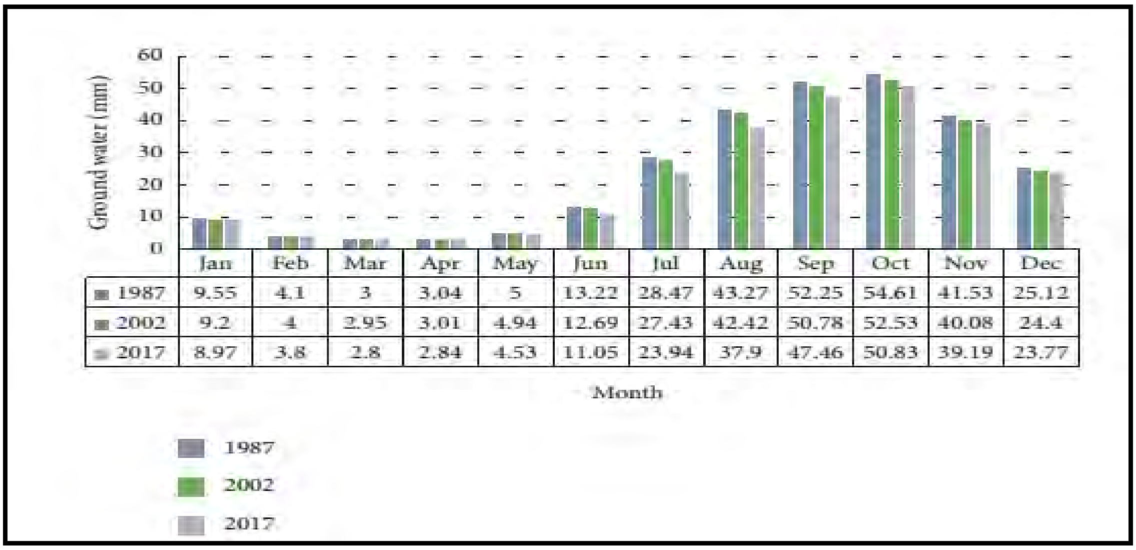
In Baro-Akobo river basin, the open water body declined around 547.94% in the past four decades (Taye et al., 2016). Results from Tewodros et al.(2021) analysis on the monthly surface runoff also revealed that, the mean monthly (wet and dry) flow has increased from 82.9 mm and decreased 20.54 mm from 1987 to 2017 in upper Baro basin (Fig. 8). Decreases in base flow have a potential effect on the change in annual river flow; as a result on ground water recharge effect (Fig. 9) (Tewodros et al., 2021).

The annually surface runoff in the basin was increased from 713.85 mm to 760.49 mm, while the groundwater was decreased from 283.21 mm to 257.13 mm in the years 1987 and 2017. Also, surface runoff was increased from 737.67 mm to760.49 mm, while groundwater was decreased from 266.32 mm to 257.13 mm in the year 2002 and 2017 (Tewodros et al., 2021).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1987	2.3	2.26	7.41	14.88	65.68	116	128.5	151.1	125.2	64.75	24.52	11.23
2002	2.48	2.42	8.08	16.08	68.07	118.3	131.7	154.9	129.2	66.96	25.35	11.67
2017	2.75	2.73	9.28	17.84	71.05	120.6	134.4	159.4	133.8	69.94	26.54	12.17

Fig. 8 Mean monthly surface runoff (mm) trends (1987-2017) in Upper Baro basin (Tewodros et al., 2021).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1987	9.55	4.1	3	3.04	5	13.22	28.47	43.27	52.25	54.61	41.53	25.12
2002	9.2	4	2.95	3.01	4.94	12.69	27.43	42.42	50.78	52.53	40.08	24.4
2017	8.97	3.8	2.8	2.84	4.53	11.05	23.94	37.9	47.46	50.83	39.19	23.77

Fig. 9 Mean monthly groundwater recharge (mm) trends (1987-2017) in Upper Baro basin (Tewodros et al., 2021).

4 Conclusion

The land degradation in Baro-Akobo basin is caused maily by the massive resettlement, commercial farming expansion and over utilization of resources. This is due to the increase of population growth that causes the increase in demand for cultivation land for different agricultural products. This resulted deforestations, soil erosion and water degradation in the basin. This demands that, strong government policy on rapid population growth, land use and land management activities in the basin.

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