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Assessment of Surface Water Resources Based on Different Growth Scenarios, for Borkena River Sub-basin, Awash River Basin, Ethiopia

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Abstract

The total annual river flow at the Awash Kombolcha sub-basin of the Borkena river station was estimated to be 4.6 billion cubic meters by 2019-2030. The current average annual flow at the exit measurement station is 544.5Mm^3 of the water resources available in the study area. The monthly peak flow of the Borkena River occurs from July to September. In addition, the highest monthly average flow is in August and the lowest is in June, with values of 150.7 million m^3 and 6.1 million m^3 respectively. WEAP model performance or model calibration was simulated between 1998 and 2018 and quantitative statistics were calculated for each previously observed flow coefficient of determination, R2, Nash Satcliff efficiency, etc. Percent bias, evaluated using PBIAS), then R2 = 0.988 and NSE = 0.70 PBIAS = 0.8 results. Assuming a relatively low reserve flow of over 92% corresponding emission analysis concept of 142 million population was considered as input. The performance balance of the model is 2019 demand data and simulated flow data at the Khemiessy exit supply. In the 2030 average growth scenario, the herd of livestock increased again by 1,610,161 to 1,776,937, with a corresponding growth rate of 0.7% per annum of 81.9 million m^3. This means that annual water usage has increased by 90.5% compared to the current scenario. Other optional implants such as rainwater harvesting, surface water harvesting, and groundwater need to be booked to meet the peak demand for dry months where the availability of surface water resources in these scenarios is felt in all water utilization sectors.

Keywords: *Awash River Basin, Borkena River, WEAP, Surface Water, CROPWAT 8.0*

1. Introduction

1.1. Background

Water is a basic necessity for the maintenance of life and the development of society, and the demand for water has increased rapidly over the years as the population grows, including urbanization, economic growth, industries, agriculture, and livestock (Cosgrove and Loucks, 2015). Population growth and economic development are constantly putting pressure on water resource ecosystems (Xiao et al., 2014). There is also a strong positive correlation between water demand and urbanization or population growth. Ethiopia has 12 major river basins, nine of which flow out except the Awash River basin, the Rift Valley Lake, and the Great Rift Valley, and all other rivers are cross-border, northwest, west, and southeast of the country (Tadese et al., 2020). The Awash River is located on the western plateau of Addis Ababa near Ginch on the central plateau of Ethiopia, at an altitude of about 3000 m. To assess the impact of demand scenario analysis to improve surface water availability and water resource planning and monitoring, the Awash basin has six planned areas: upstream Awash Coca, Awash Awash, Awash Haridebi, and Awash Adaitu. , Awash Terminal, is divided into Eastern Submersibles. -Basin (Belayneh, 2018). The Awash Koka sub-basin includes the Awash Kuntre, Mojo, and Akaka rivers. Awash in the lower reaches of Awash includes the Keletawerenso and Awashalva rivers 1 and 2, and the lower reaches of Awashharidebi include the Kesemkebena, Ankova, Negesogera, Awadi, and Gedevasa Wetlands. The lower reaches of the Awash River Terminal include the Mile and Logia Rivers (Kerala, 2019). Desertification has already begun in the lower and central parts of the Awash River basin. At the top, deforestation and sedimentation have increased over the last 30 years (Tufa, 2021; Kebede,2013).

As more water is drawn from the river, it can lead to dramatic ecological changes and environmental flow that endanger the Borkena River in the habitat and human life of the Awashkom Borkena subbasin (Belachew, 2019). Increasing water demand will reduce the availability of surface water available to users in the dry season, and water conflicts in catchment areas will continue to increase. Unless water resources are properly managed. In particular, at the Awash Kombolcha Borkena Subbasin on the Borkena River in north-central Ethiopia, a relatively large number of large production facilities have been shut down, all located

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along two major tributaries of the Borkena River (Morris, 1923). In addition, Awash city is currently selected as the most important industrial corridor in northern Ethiopia. Therefore, it is clear that the availability of relevant surface water and the risk of pollution will increase in the future to meet demand. The existing industries around Awash city dump waste into rivers (Baker, 2012). In addition, the report obtained from the Awash city administration explains that many farmers and businesses have long used the river for irrigation (Zainab, 2011). As a result, no studies have been conducted on the theme of assessing surface water availability and water demand to improve water resource planning and livelihoods in the study area (Singh et al., 2014). Recent studies have shown that climate change, socio-economic activity, population growth, water pollution, and large-scale water withdrawals are the main challenges that have changed the natural water balance of the Borkena River (Bezabih and Mosissa, 2017).

Poor management of water resources, increased competing water demand for self-sufficiency, and lack of strong management and coordination between sectors are expected to exacerbate the water scarcity challenge in catchment areas (Kahil et al., 2015). This means that proper planning and development of water resources are needed. This requires empirical evidence of current and future surface water availability and demand in the Kombolcha basin of the Borkena River. This study fills this gap and provides sufficient information on water supply and demand in river basins that are important to decision-makers in the water sector. Studies show that the main challenges faced by climate change, socio-economic activity, population growth, water pollution, and the naturally altered hydrological regime of the Borkena River are the extraction of large amounts of water (Francés et al., 2017).

The objective of this research was to assess surface water resources based on different growth scenarios, for Borkena River sub-basin, Awash River Basin, Ethiopia. As Ethiopia is heavily affected by global surface water fluctuations, it is very important to anticipate future needs for better awareness and better preparation to mitigate the associated surface water scarcity. The question is whether the future impact of supply and demand imbalances on hydrology in the Awash Kombolcha Borkena subbasin of the Borkena River is another purpose of this research paper, as there is no research on this topic in this area.

2. Materials and Methods

2.1. Description of Study Area

Geographically, the Awash Kombolcha Sub Basin lies between 1154573.2 meters to 1249931.1 meters north and 550396.7 meters to 603.9526 Km east in UTM coordinates, with an altitude range of 1394 to 3513 meters above sea level, with a total area of 1258. It is 4km^2. The Awash Kombolcha Sub Basin in the Borkena basin is named after the city of Kombolcha, located in the north-central part of Ethiopia, just southeast of Dessie, Amhara. The Borkena River crosses the town of Kombolcha in the basin, flowing east and west. As shown in Figure 1, most factories are located close to the middle of the city near these tributaries (Yohannes and Elias, 2017).

2.2. Population

Awash Kombolcha Sub-Basin has 12 woreda and 91 kebeles including Kombolcha, Kemisie, Albuko, Dessie, Chaffie golana dawe, Kutaber, Ancharo, gisheRabel, Tehulederie Anstokian Gemez, Artuma, and Harbu/Kalu are woredas or towns found in the study area. The towns or woredas in this study area are known for their high animal and human population density with different ethnic groups and religions. According to the data obtained from the Ethiopia Central static agency, the current population of the Woreda in the study area is estimated at 1,734,366 of which 544,111are urban and the remaining 1,190,255 are rural, which is 54.3% of the total population in this area (Teklehaymanot, 2017).

2.3. Rainfall and Climate

Rainfall and temperature are the prime factors in determining the climate and therefore the distribution of vegetation types (Fax et al., 2017). The study area is characterized by two rainy seasons (quasi-bimodal rainfall pattern). The main or the longer rainy season is during Kiremt extends from (June- September) which supports the major crop production while the small or the shorter rainy season is during Belg extends from (March-May) and allows minor crop production (Fax et al., 2017). The physiographic characteristics of the study area include an altitude of 1394 up to 3513 meters above sea level (Shumet and Mengistu, 2016). The area receives a mean annual rainfall of 710.94 mm at the Upper Part Kombolcha Station to 648.6 mm at the lower part of Kemisie station with annual average maximum and minimum temperatures of 27.1°C and 11.6°C at Kombolcha and 32.9°C and 13.2°C at Kemiessie, respectively.

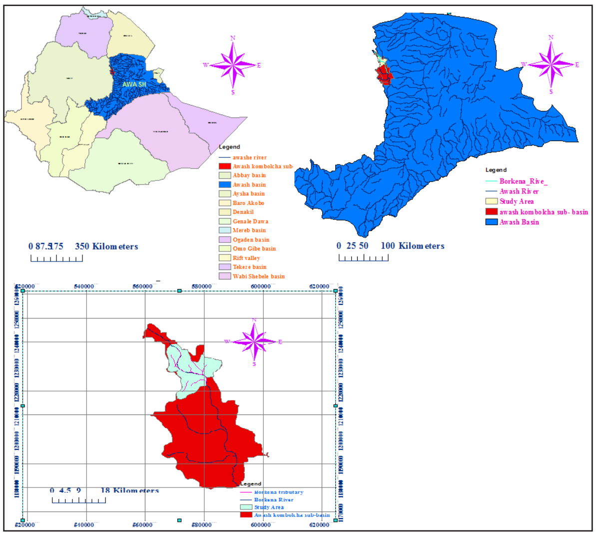


Figure 1. The drainage system and location of the study area

2.4. Data Collection

The sources of the data are the Ministry of Water, Irrigation and Energy, the Ethiopian Mapping Authority, the National Meteorological Service, and documents. Water demand data for each sector were collected from the Ethiopian Water Sector Development Master Plan based on (Shumet and Mengistu, 2016). The required measurement data include precipitation, maximum and minimum air temperature, solar radiation, wind speed, and daily relative humidity. If any of these data are not available, most likely, estimate the required output using the WEAP and Crop Wat modeling program. This data for the remaining stations are loaded at dawn from the global weather data for SWAT. Monthly observational data are required for entry (WEAP) as headwater flows into the study area. These data are taken from the hydrology department of the ministry of water, irrigation, and energy for the period 1998 - 2018. The discharge data is collected and sorted according to the requirements of the model (WEAP). A digital elevation model (DEM) is any digital representation of a terrain surface and is specifically made available as a raster or regular grid of point elevations. The watershed of the Borkena River has been delineated and river networks have been driven from the DEM with a resolution of 90 m x 90 m.

2.4.1. Hydro-meteorological data Analysis

In the analysis of hydrological data, the stations were required to have daily records for the required period of observation (1998-2018) years. Sometimes a particular flow gauge was not functional for a part of a month or year. It then becomes necessary to fill in missing records. In this thesis, arithmetic means the value of the entire period was used to fill the missed records for the stations with less than 10 percent missed records while for the stations having greater than 10 percent of missed records normal- ratio method was used as per Table 1 using excel Extension software named XLSTAT 2018 version.

Table 1. Description of the streamflow recording stations with percentage missed

Station Name	Latitude	Longitude	Recorded period	Missing %
Borkena at swamp outlet	10:38: 0 N	39:56: 0 E	1998 – 2018	3.32%
Borkena at Nr. Albuko	11: 3: 0 N	39:44: 0 E	1998 – 2018	14.43%
Borkena Rr.Nr.kombolcha	11:13: 0 N	39:37: 0 E	1998 -2018	4.39%

Failure of a rain gauge or the absence of an observer from a station causes a brief interruption of rainfall recordings at the station. These gaps must be filled before precipitation data can be used for analysis. The surrounding stations located in the study area help to supplement the missing data on the hydro-meteorological similarity hypothesis of the station group. , and the inverse distance method. This method is used when the normal annual rainfall of the indicator stations differs by more or less than 10% from the deficient station. The precipitation of the surrounding index stations was calculated as an arithmetical and normal ratio o the annual precipitation using the following equations 1 and 2. rainfall recording stations with percentages of missed values are shown in Table 2.

$$\mathrm{Pm} = \sum_{i=1}^{n}\left(\frac{\mathrm{Nm}}{\mathrm{Ni}}\right)\mathrm{Pi} \quad \text{.......} (1)$$

$$Pm = \frac{p1+p2+p3......+pn}{n} \quad \text{.......} (2)$$

Table 2. Description of the rainfall recording stations with percentage missed value

S/No	Station Name	Longitude (E)	Latitude (N)	Area (Km²)	Missing (%)
1	Dessie	39.63	11.12	136.014	10.81%
2	Maybar/Ancharo	39.63	11.05	131.771	16%
3	Combolcha	39.72	11.08	261.995	13.05%
4	Kemissie	39.87	10.72	190.195	4.43
5	Albuko	39.7142	10.8139	538.409	16.7
	TOTAL			1258.38	-

A consistent record is one in which the characteristics of the record do not change over time. Adjusting for metric consistency involves estimating an effect rather than a missing value. The consistency of precipitation profiles at selected stations is usually checked by dual-mass curve analysis. If the relevant conditions for recording a station, the precipitation data undergo a significant change throughout the recording time, there will be inconsistencies in the precipitation data from this station. This inconsistency can be distinguished from when significant changes have taken place. If a significant change in the mode of the curve is observed, it should be corrected using Equation 3.

$$\mathrm{Pcx} = \mathrm{Px} * \frac{\mathrm{Mc}}{\mathrm{Ma}} \quad \text{.......} (3)$$

Uniformity is an important issue for detecting data variability. In general, when the data is homogeneous, it means that the data measurements are made with both the same equipment and the same environment. However, it is a difficult task when dealing with precipitation data because it is always caused by changes in measurement techniques and monitoring procedures, environmental characteristics and structures as well as the location of the precipitation station. One of the methods to check the uniformity of the selected stations in the study area is to record the rainfall without dimensions and draw a graph to compare the stations with each other. The monthly spacetime precipitation values for each station can be calculated using Equation 4.

$$Pi = \frac{Pi,av}{Pav} * 100 \quad \text{.......} (4)$$

Where:

Pi is the dimensionless value of the monthly rainfall at station i, Pi, av is the average monthly rainfall over the years for station i, and Pav is the average annual rainfall for the station when the precipitation regimes are the same or vary in a range they can consider as uniformity.

2.5. Estimation of Areal Rainfall

The rain gauge is a one-time measurement only. In practice, however, hydrological analysis requires knowledge of precipitation over an area. Several approaches have been designed to estimate surface precipitation from Isohyetal point measurements: isohyets are lines connecting locations of equal rainfall intensity across a watershed. In this research, the aging method is used to determine the average rainfall over the whole area since the rain measurements are uniformly distributed. Surface precipitation in the study area is calculated using Equation 5.

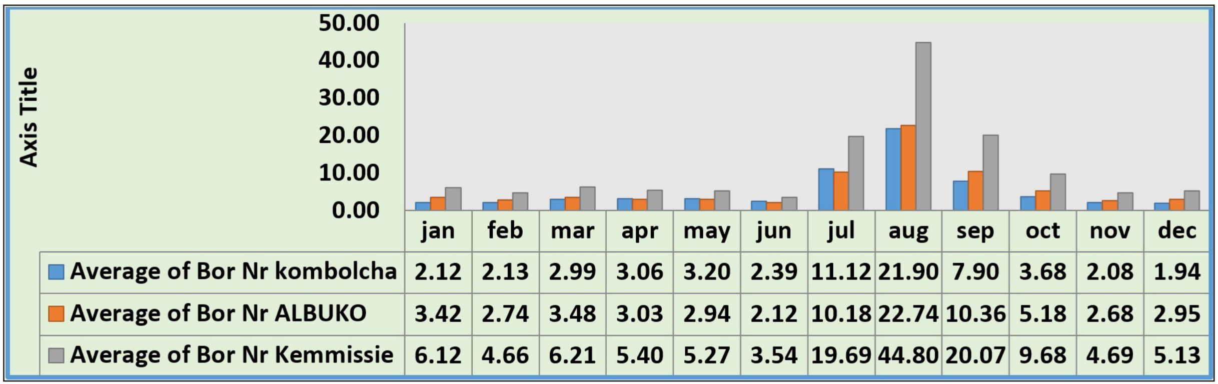
$$Pav = \frac{P1+P2+P3+P4----------+Pn}{n} \quad \text{..........................} (5)$$

Where, P_{av} average areal rainfall (mm), P_1, P_2, P_3, P_n precipitation of station 1, 2, 3...n, respectively. In this method, the sums of each gauge are inversely proportional to the sample size of the rain gauge station.

2.6. Water Supply Data

2.6.1. Stream Flow

Flow streams should be continuously recorded to accurately assess surface water availability. Flow records that represent natural history and hydrology unaffected by humans are the basis for watershed hydrological modeling (WMO). Flow data is collected from the office of the Ethiopian Ministry of Water, Irrigation, and Energy, and flow discharge is an important aspect of the modeling of flows. Data available for the rivers were obtained from three gauging stations namely, Borkena at swamp outlet Nr Kemmisie, Borkena at Nr. Albuko, BorkenaRr. Nr.Kombolcha. The mean monthly flow data from this gauge station were used for the WEAP model shown in Figure 2.

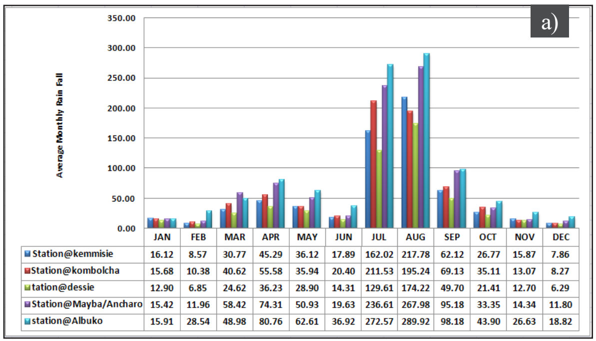


	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Average of Bor Nr kombolcha	2.12	2.13	2.99	3.06	3.20	2.39	11.12	21.90	7.90	3.68	2.08	1.94
Average of Bor Nr ALBUKO	3.42	2.74	3.48	3.03	2.94	2.12	10.18	22.74	10.36	5.18	2.68	2.95
Average of Bor Nr Kemmissie	6.12	4.66	6.21	5.40	5.27	3.54	19.69	44.80	20.07	9.68	4.69	5.13

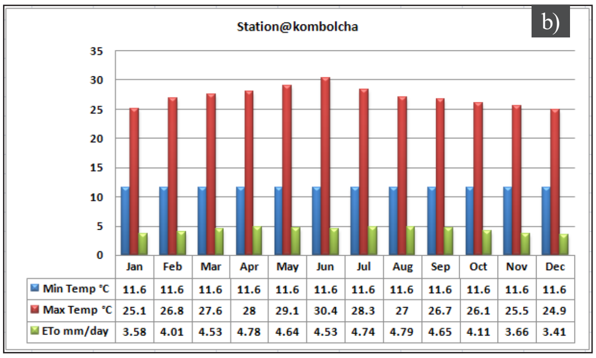
Figure 2. Average streamflow of Borkena River in a different station (Gummadi et al., 2018)

2.6.2. Rainfall and Temperature

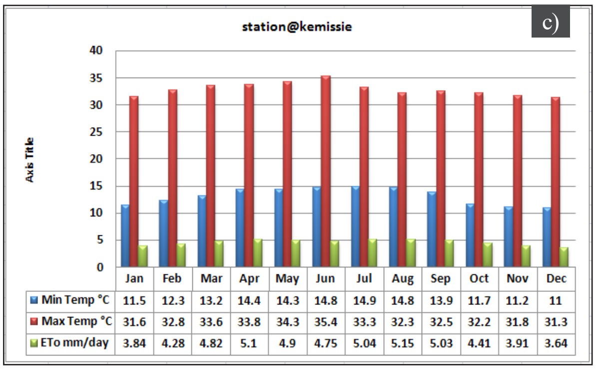
Rainfall and temperature are the prime factors in determining the climate and therefore the distribution of vegetation types (Subramoniam et al., 2013). There is a strong correlation between climate and biomass in the study area to quantify current surface water availability to analyze demand scenarios for the future. The study area is characterized by two rainy seasons (quasi-bimodal rainfall pattern). The physiographic characteristics of the study area include an altitude of 1394 up to 3513 meters above sea level (Polidori and El, 2020; (Gummadi et al., 2018). The area receives a mean annual rainfall of 710.94 mm at the Upper Part Kombolcha Station to 648.6 mm at the lower part of Kemisie station with an annual average maximum and minimum temperature of 27.1 C° and 11.6 C° at Kombolcha and 32.9 C° and 13.2 C° at Kemiessie, respectively in the present study figures 2 and 3.



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Station@kemmisie	16.12	8.57	30.77	45.29	36.12	17.89	162.02	217.78	62.12	26.77	15.87	7.86
Station@kombolcha	15.68	10.38	40.62	55.58	35.94	20.40	211.53	195.24	69.13	35.11	13.07	8.27
tation@dessie	12.90	6.85	24.62	36.23	28.90	14.31	129.61	174.22	49.70	21.41	12.70	6.29
Station@Mayba/Ancharo	15.42	11.96	58.42	74.31	50.93	19.63	236.61	267.98	95.18	33.35	14.34	11.80
station@Albuko	15.91	28.54	48.98	80.76	62.61	36.92	272.57	289.92	98.18	43.90	26.63	18.82



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min Temp °C	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6
Max Temp °C	25.1	26.8	27.6	28	29.1	30.4	28.3	27	26.7	26.1	25.5	24.9
ETo mm/day	3.58	4.01	4.53	4.78	4.64	4.53	4.74	4.79	4.65	4.11	3.66	3.41



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min Temp °C	11.5	12.3	13.2	14.4	14.3	14.8	14.9	14.8	13.9	11.7	11.2	11
Max Temp °C	31.6	32.8	33.6	33.8	34.3	35.4	33.3	32.3	32.5	32.2	31.8	31.3
ETo mm/day	3.84	4.28	4.82	5.1	4.9	4.75	5.04	5.15	5.03	4.41	3.91	3.64

Figure 3. a) Average monthly Rainfall of all stations in the study area b) Average monthly Max and Min temperature of Kombolcha station in the study area c) Average monthly Max and Min temperature of Kemiessie station in the study area

2.7. Materials

2.7.1. GIS for Watershed delineation

Determination of the study area boundary and stream delineation was done using the spatial analyst tool in ArcGIS version 10.4.1, using various thematic maps such as topography, drainage, and land cover/use.

2.7.2. CROPWAT

The CROPWAT 8.0 software was used in calculating crop water requirements. This software uses monthly averages of the climatic parameters. The ETo is calculated using the Penman- monteith method and effective rainfall is estimated by the FAO formula. The software provides data on crops such as Kc, growing stage, rooting depth, and soil moisture as defaults.

2.7.3. Water Evaluation and Planning

Water assessment and planning software was selected for this study. The WEAP model essentially calculates the mass balance of sequential flows along with a river system, taking into account withdrawals and inflows. The elements that make up the water demand system and their spatial relationships are featured in the model. In this thesis, WEAP is used because it has an integrated approach to simulate both natural and engineering components such as reservoirs, international groundwater discharge, and water demand and supply, this can provide water planners with a more complete view of the range of factors that must be taken into account in managing water resources for current and future uses. In Ethiopia, WEAP was exactly performed in 2016 to assess competitive irrigation and water demand scenarios in the Didessa Sub-Basin (Adgolign et al, 2016).

2.8. Methods Analyzed

The water system simulation model helps to understand the relationship between available water resources and the demand for these resources under current and future development scenarios. Basin modeling using WEAP involves the following steps i) Define study area and period ii) Create current account iii) Generate scenarios iv) Evaluate scenarios. With WEAP, the first Current Account of the water system under study is created. Then, one or more simulation scenarios are developed with alternative hypotheses about future development. Situations can answer many types of "what if" questions. The simulation of the model is structured as a set of scenarios with monthly time steps. WEAP21 solves the problem of water allocation through linear programming to maximize the satisfaction of a demand node constrained by water availability, demand priority, the priority of source of supply, and how close the supply is.

2.8.1. Catchment's delineation

The river system has been mathematized using the Arc View GIS layer. The runoff from the catchment nodes in WEAP21 represents the head flow of the streams. In this study, arithmetic means the method is used to generate the aerial precipitation over the catchment. Precipitation in the area was estimated using the arithmetic mean for the selected period from 1998 to 2018 (of the eight rain stations in the basin, only five have complete monthly rainfall data). from 1998 to 2018). Monthly mean of potential monthly evaporation. The Penman-Monteith method is recommended as the only standard method for determining and calculating the Reference Evaporation is generated using Crop Wat while the Kc coefficient is obtained from Crop Wat. Geometric population growth and precipitation method (simplified coefficient method) were used in WEAP. The Rainfall Flow (simplified coefficient) method in WEAP21 was used to simulate the catchment (flow) process. This method determines land use by the crop factor, Kc, catchment area, and effective precipitation while climate is determined by reference precipitation and transpiration, ETo.

2.8.2. Cropwat 8 model setup

CROPWAT is a decision support system developed by the FAO Department of Land and Water Development for irrigation planning and management. The Food and Agriculture Organization (FAO) CropWat8 model was used to simulate the seasonal irrigation pattern observed with different growing seasons in the region. The measured data of the study area was used to generate the actual evaporation (ETo), Kc, and the actual rainfall of the study area and the monthly irrigation demand ratio to be used as the entry for the WEAP model.

2.8.3. WEAP Model

The WEAP model was developed by the Stockholm Environment Institute (SEI) and can be downloaded from www.weap21.org. It is a general-purpose multi-reservoir simulation program that determines the optimal water allocation for each time step on the fundamentals of water balance calculations. The model provides a comprehensive, flexible, and user-friendly framework for policy planning and analysis. According to (SEI), WEAP integration is listed as follows i) GIS-based drag and drop graphical interface ii) Physical simulation of water demand and supply iii) Additional simulation model: variables created users create, model equations and link to spreadsheets and other models iv) Scenario manageability v) Homogeneous modules on hydrology, water quality and watershed finance vi) Developed by the American Center for the Stockholm Environment Institute Integrated Model of Watershed Hydrology and Planning. The advantage of WEAP (Water Evaluation and Planning) is a software tool for integrated water resources planning. It provides a comprehensive, flexible, and user-friendly framework for policy analysis. Its disadvantage is that building a model requires data, time, modeling skills, and patience.

2.9. Model Evaluation Statistics

The quantitative statistics used to evaluate the performance of the model are the coefficient of determination (R2), the efficiency of the Nash-Sutcliffe model (NSE), and the percentage deviation (PBIAS)

2.9.1. Coefficient of determination (R2).

The coefficient of determination (R2) describes the years' congruence between the simulated and observed data. R2 describes the proportion o the observed data variance explained by the model. R2 ranges from 0 to 1, gives higher values, sh less error variance. Rs values greater than years 0.5 are considered acceptable (IOPConf, 2017). The calculation of R2 is presented as follows.

$$R^2 = \left[\frac{\sum_{i=1}^{n}(\text{yisim} - \check{y}\text{sim})(\text{yiobs} - \check{y}\text{iobs})}{\sqrt{\sum_{i=1}^{n}(\text{yisim} - \check{y}\text{sim})^2 \sum_{i=1}^{n}(\text{yiobs} - \check{y}\text{iobs})^2}}\right] .. (6)$$

Were, Yi, Obs: the ith stream of observations, Jim: the ith simulation stream, y̌obs: the average value of the observed stream, y̌isim: the average value of the simulation stream.

2.9.2. Percent bias (PBIAS)

Percent bias (PBIAS) measures the average tendency of simulated data to be larger or smaller than the observed data. The optimal value of PBIAS is 0.0, with low amplitude values indicating an accurate simulation of the model. A positive value indicates the estimated bias of the model, and a negative value indicates the acceptable estimated bias for the model (IOPConf, 2017). PBIAS is calculated as shown below.

$$Percentage\ BIAS = \left[\frac{\sum_{i=1}^{n}(yiobs - yisim)}{\sum_{i=1}^{n} yiobs} * 100\right] \cdots (7)$$

2.9.3. Nash-Sutcliffe efficiency (NSE)

Nash Sutcliffe Efficiency (NSE) is a normalized statistic that determines the relative magnitude of residual variance ("noise") to the variance of measured data ("information") (IOPConf, 2017). NSE tells how closely the histogram of the observed versus simulated data matches the 1:1 line. NSE ranges from −∞ to 1 (including 1), NSE 1 is the optimal value. Values between 0.0 and 1.0 are generally considered to be an acceptable performance level, while values etlt; 0.0 indicates that the observed mean is a better predictor than the simulated value, indicating unacceptable performance (IOPConf, 2017). NSE is calculated as shown below.

$$NSE = 1 - \left[\frac{\sum_{i=1}^{n}(yiobs - yisim)^2}{\sum_{i=1}^{n}(yiobs - yisim)^2}\right] \text{.........................} (8)$$

Were,

Yi, Obs: the ith observed streamflow, yiSim: the ith simulated streamflow

2.10. Reference Scenario and Model Configuration

Reference scenarios are baseline scenarios that use real-world data to help you understand the best estimates during the study period. In this scenario, an existing dataset from the study area was used. This data entry in WEAP is structured according to the schematic structure of the survey boundaries and is the basic scenario for the following scenarios and the required sub-scenarios. This happened in the next step (Shumet and Mengistu, 2016). The model was initially configured to simulate a base year or current situation scenario that could reliably determine water availability and demand. What if scenario analysis is set up and the simulation runs from 2019 to 2030. The scenario is based on the data from the previous scenario. Therefore, the following scenarios formed the basis of the reference scenario development of reference scenarios (2020-2030).

2.11. Scenario Analysis and Model Development

2.11.1. Current account of water demand

Current water billing sectors are identified in the study area to simulate the water demand available in the current account balance between these sectors. The categories of demand are household, agriculture, livestock, environment, and industry. The input data request for the WEAP model was created by adding a GIS-based raster map and vector map to the projection area, and the background vector data was added from the shapefile format. This format was created by the ArcGIS 10.4.1 software when the area was opened and the year, time steps, and units were set. In this survey, the current balance of payments for the year (2019) in the start year scenario until the end of 2030, the time stepper year is set to 12, and the time step limit is set to "based on the calendar month". January. The year of the current account is selected as the basis of the model and all system information (such as supply and demand data) is included in the performance balance. Performance accounts are the dataset from which scenarios are created. In the "Current Scenario", the current account data will be transferred to the entire project up to (20202030). The flow path is drawn in WEAP by clicking the Flow symbol in the element window. WFAP has a module for modeling hydrological processes. The hydrological model is semi-theoretical, continuous-time, semi-distributed, and deterministic. Since the model is semi-theoretical, it must be calibrated to verify the model's performance. To develop the structure of the model, the entire study area was divided into five (5) hydrological basins (according to available hydrological data) and six (6) possible demand sites taking into account the needs of the population. domestic and non-domestic demand. In addition, it has three (3) flow measurement points and five rain gauge stations located in the study area. Next, the structure of the model is developed by taking into account relevant factors, including the river (flow), demand location, transmission link, watershed, and flow discharge, for steps of monthly time from 2020 to 2030. Figure 4: is a diagram of the model showing the topology of a network of WEAP nodes stacked with several GIS layers. Hence, several scenarios have been developed and identified in the model to study surface water problems and water problems that may arise shortly.

A demand site is best defined as a collection of water users who share a common physical distribution system, all of whom are located in a defined area, or who share a common point of primary supply and priority system. The water demand per site is calculated with the total volume/area which is the annual water demand per unit area (m^3/ha) or per person/population / as well as monthly variations. The schematic illustrations are provided in Figure 4.

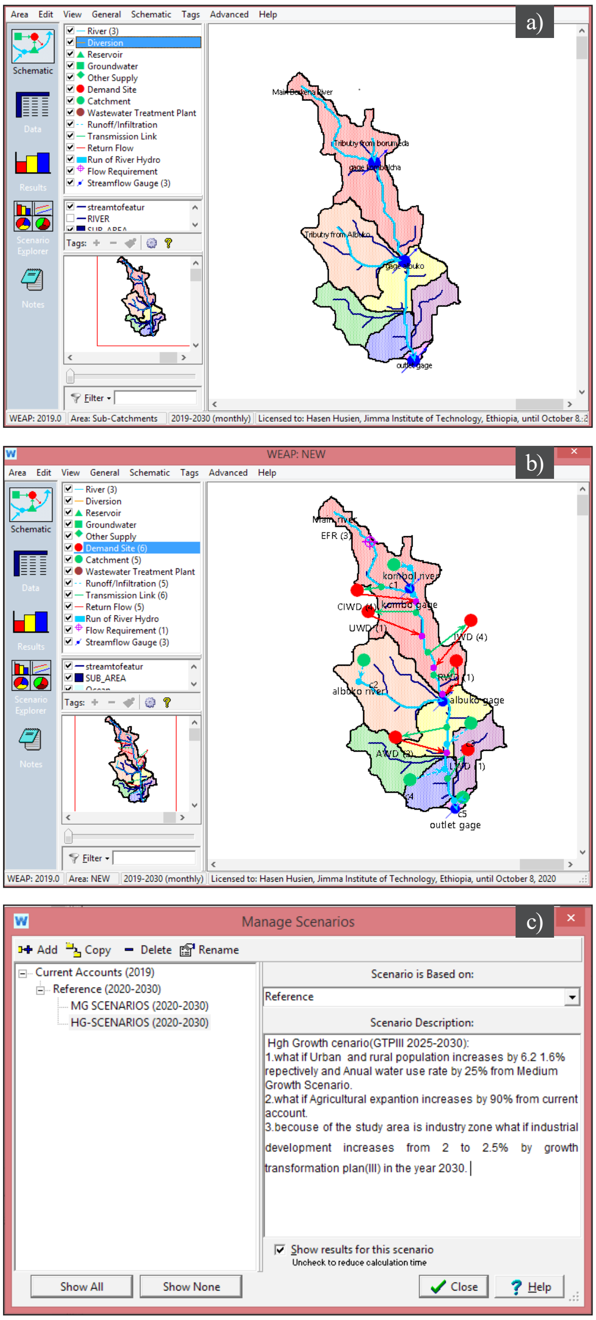


Figure 4. a) Data input into WEAP interface and Catchment boundary in WEAP model development b) Schematic illustration of the Awash Kombolcha sub-basin of Borkena watershed in WEAP c) Creation of Scenarios in WEAP

2.11.2. Current scenarios

The base scenario is also known as the default scenario set from current accounts, it represents the basic definition of the current system including the specification of first-year supply and demand data. First, the monthly study stimulates the likelihood of system growth without intervention (Aung et al., 201). In this study, the current scenario applied to the Borkena river situation analysis does not have any development of the system, except for the population growth rate of 7, and 1.3% per year, respectively. In urban and rural areas and the average annual growth rate of livestock is estimated at 0.7%.

2.11.3. Medium Growth (MG) scenario

After analyzing the possible impact in current scenarios WEAP was configured in medium growth scenarios, these scenarios are to evaluate the impact of a population growth rate and extended Agricultural area for the study area. The medium growth (MG) scenario is assumed considering the urban population growth rate increase from 4.7 to 5% per annum and rural population growth rate of 1.8% and livestock population 0.85% and agricultural land expansion by 6.6% which reach 11,326 ha to 23,680 ha in the medium Growth Scenario as obtained from the Awash city administration.

2.11.4. Higher growth (HG), scenario

The socio-economic development activities in the Awash River Basin such as investment in agricultural development through irrigation, land conversion by pastoral groups, and the expansion of industries due to expansion of output markets and macro-economic policy support are expected to be the major drivers of land degradation challenges. This process can be strengthened in association with the expansion of urbanization and population growth which will add pressure on water, land, and related resources in the basin (ABA, 2017). Agricultural growth is assumed to be 7.6%, it reaches 23.680 ha to 35,450 ha it shows a 90% increment when comparing from current scenario industrial growth 2 to 2.5 % by Growth transformation plan (III) by the year 2030.

2.11.5. Environment flow

In the annual discharge of the river Borkena, it is assumed that the current amount of river flow will be constant for up to three scenarios, also the minimum environmental flow requirement will be constant in the three scenarios since there is no reliable projection in the study it can be increased or reduce in the environmental flow.

3. Results and Discussion

3.1. Surface Water Availabilities

3.1.1. Stream Flow

The available data for the Awash Kombolcha sub-basin of the Borkena river watershed, 20-year data were taken to estimate the river flow at Swamp outlet near Kemiessie, which is the outlet of the sub-basin. The total river flow at this station has been estimated at 4.6 BCM by 2019-2030 but the current average annual at the outlet gage station has been estimated to be 544.5Mm^3 of the available water resource in the study area by (2019). The higher flows for 2019, 2020, 2021, and 2022. The peak monthly flow in the Borkena River is occurring from July to September, furthermore, the highest monthly average flow occurs in August and the lowest occurs in June with values of 150.7 and 6.1 M m^3 respectively. The annual and monthly streamflow data is illustrated in Figure 5 and Table 3.

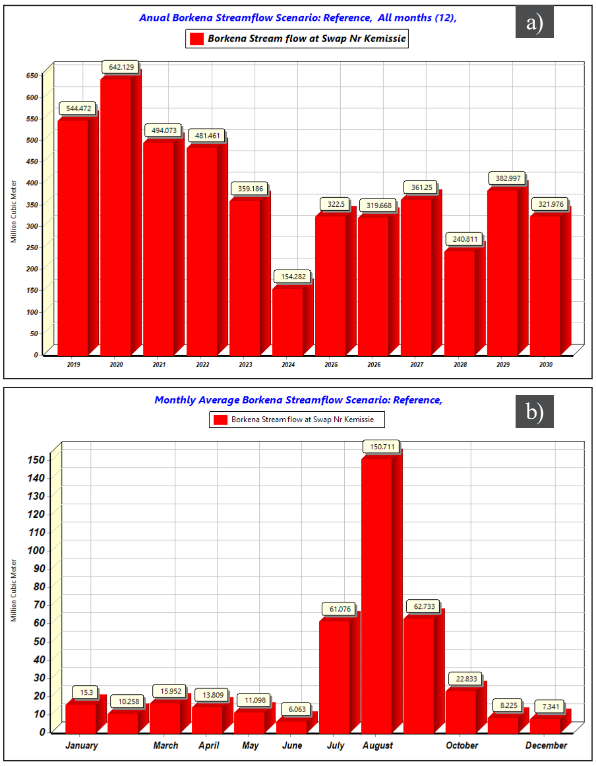


Figure 5. a) Annual Streamflow data at swamp outlet (2019-2030) b) Monthly average Streamflow data at swamp outlet (2019-2030)

Table 3. Annual and monthly Borkena Stream Flow (MCM) at Swamp outlet Nr Kemiessie

Year 2019-2030	Annual streamflow (Mm^3)	Monthly Current-2019	monthly streamflow (Mm^3)
2019	544.47	Jan	15.3
2020	642.13	Feb	10.26
2021	494.07	Mar	15.95
2022	481.46	Apr	13.81
2023	359.19	May	11.1
2024	154.28	Jun	6.063
2025	322.5	Jul	61.08
2026	319.67	Aug	150.7
2027	361.25	Sep	62.73
2028	240.81	Oct	22.83
2029	383	Nov	8.225
2030	321.98	Dec	7.341
Sum	4624.8	-	385.4

3.1.2. Precipitation over the Kombolcha sub-basin of Borkena River

The results show that the Borkena basin's Kombolcha sub-basin receives an estimated 63.3 MCM of rainfall per year. Table 4 relays what could improve rainwater harvesting in the study area. The highest monthly rainfall occurs from July to September and decreases from March to May. In addition, the highest average monthly rainfall in the region occurs in July and the lowest in February with values are 13.58 and 1.11 M m3 respectively. The precipitation of the five basins shows significant spatial and temporal variations.

Table 4. Observed Precipitation Monthly Average (MCM) in kombucha Sub-basin

Month	c1	c2	c3	c4	c5	Sum
Jan	2.68	2.31	2.25	1.60	0.11	8.95
Feb	1.99	1.56	1.52	0.92	0.07	6.05
Mar	1.49	1.80	1.29	1.17	0.05	5.79
Apr	0.84	0.43	0.21	0.67	0.03	2.17
May	1.99	1.41	0.84	1.65	0.07	5.96
Jun	1.01	1.24	1.38	0.57	0.04	4.23
Jul	2.32	1.03	1.14	0.98	0.07	5.54
Aug	0.66	0.80	0.40	0.54	0.02	2.42
Sep	1.43	1.06	0.65	0.86	0.05	4.04
Oct	0.72	1.20	0.88	0.63	0.03	3.46
Nov	1.56	1.69	1.24	2.00	0.05	6.54
Dec	2.24	2.24	1.18	2.41	0.08	8.15
Sum	18.93	16.76	12.96	14.01	0.66	63.32

Note; C1, C2, C3, C4, and C4 are catchment 1, catchment 2, and catchment 3. catchment4 and catchment5. The water balance of simulations shows that on average, 27.8 % of rainfall contributes to the surface and subsurface flow and 72.2% is evapotranspiration.

3.1.2.1. Runoff generated from precipitation

The runoff generated from the rainfall of the study area has been estimated using the water balance, the rainfall-runoff method in the WEAP model. As a result of the calculations, based on the Rainfall-Runoff method in WEAP, it was found that the total annual surface runoff from given precipitation in the Study area is 17.60 (MCM) Table 5: which is 27.8 % of total surface water availability from precipitation of different station in the study area.

Table 5. Runoff Monthly Average (MCM) in Awash kombucha Sub-basin.The water balance of the study area is indicated in Figure 6.

Year	Runoff from C1 to Kombol river	Runoff from C2 to the Main river	Runoff from C3 to the main river	Runoff from C4 to the main river	Runoff from C5 to the main river	Sum
Jan	0.96	1.02	0.25	0.21	0.03	2.46
Feb	0.72	0.68	0.17	0.12	0.02	1.70
Mar	0.54	0.79	0.14	0.15	0.01	1.63
Apr	0.30	0.19	0.02	0.09	0.01	0.61
May	0.72	0.62	0.09	0.21	0.02	1.66
Jun	0.36	0.55	0.15	0.07	0.01	1.14
Jul	0.83	0.45	0.13	0.13	0.02	1.56
Aug	0.24	0.35	0.04	0.07	0.01	0.71
Sep	0.51	0.46	0.07	0.11	0.01	1.17
Oct	0.26	0.53	0.10	0.08	0.01	0.97
Nov	0.56	0.74	0.14	0.26	0.01	1.71
Dec	0.81	0.99	0.13	0.31	0.02	2.25
Sum	6.81	7.38	1.43	1.82	0.16	17.60 Mm^3

Note; C1, C2, C3, C4, and C4 are catchment 1, catchment 2 and catchment 3, catchment 4, and catchment 5

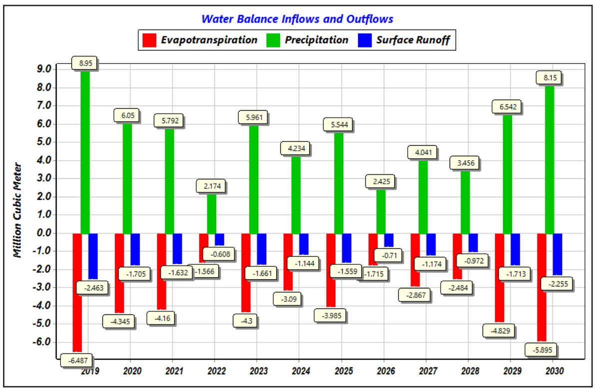


Figure 6. Water Balance of the study area (MCM)

3.2. Model Calibration

The calibration of the WEAP model for this study was based on discharges at the Borkena Wetland measuring stations near Kemissie, it was carried out between 1998-2018, and the results of the WEAP simulation are completely dependent on the quality of the data. Inputs such as hydrological and meteorological data. Model accuracy was assessed using Quantitative statistics (coefficient of determination, R2; NashSutcliffe efficiency, NSE and percent bias, PBIAS) calculated for each set of historical and model lines. simulated observations in the period 1998-2018, then I obtained the results as R2 = 0.988 Figure 7 and Table 7: and NSE = 0.70, PBIAS = 0.8, we can observe that the simulated and observed flows in the Borkena river at the measuring station, there is a good correspondence between the simulated and observed discharge values, the results show that The simulation adapts well to the observed data and the performance of the model is perfect and provides a good estimate as indicated in figure 7 and Table 6.

Table 6. Stream low at Gage station (observed Vs Simulated)

Year	Simulated	observed
2019	471.9849	544.4721
2020	572.1683	642.1291
2021	431.5058	494.0732
2022	419.3256	481.4614
2023	276.5615	359.1855
2024	97.25155	154.2819
2025	258.7808	322.5001
2026	235.1602	319.6679
2027	260.9561	361.2496
2028	183.9549	240.8115
2029	297.2647	382.9974
2030	232.2037	321.9756

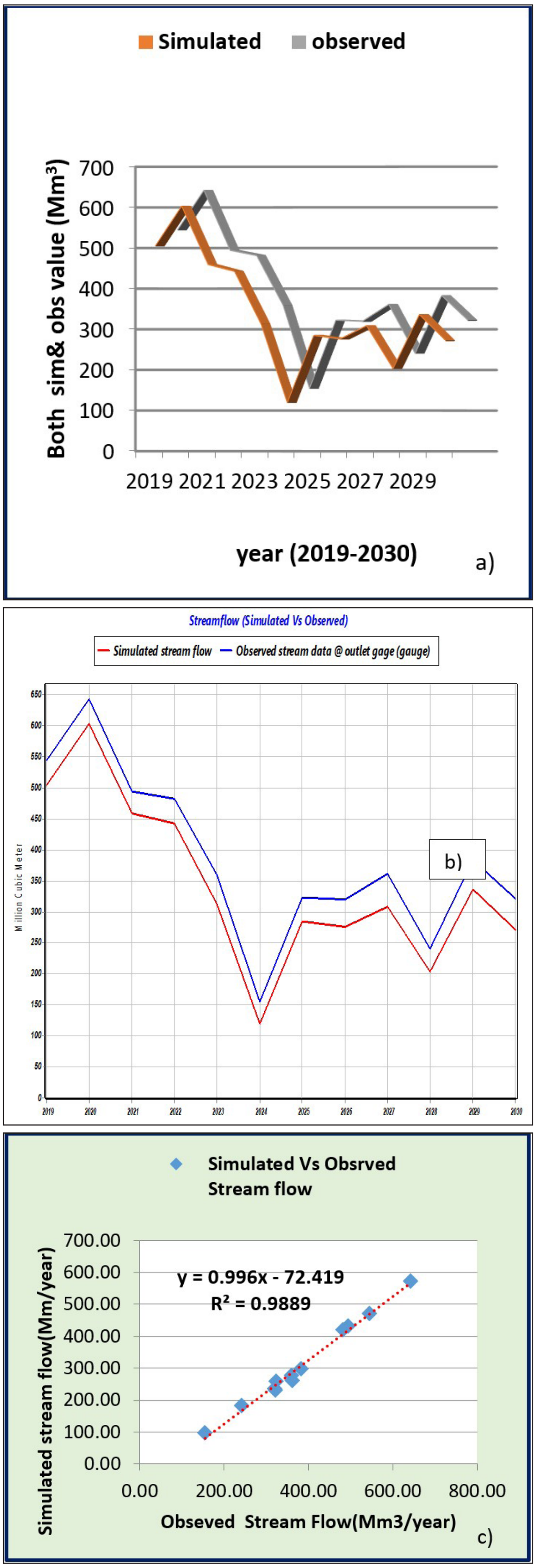


Figure 7. a) Observed and simulated streamflow in Borkena River (output from WEAP model) b) Observed and simulated streamflow in Borkena River c) Factor of determination (R2) for observed simulated Vs stram flow rate.

3.3. Environmental flow requirements

To maintain the ecological services as well as the natural channel habitat associated with the historic flow regimes of the Broken River, a certain reserve flow has to be maintained and could be considered as a sectoral demand on its own. The basic time unit used in preparing a flow duration curve was determined by sorting average monthly discharges for a period of record from the largest value to the smallest, involving a total of n values. The sorted monthly traffic values are assigned a rank (M) starting with 1 for the maximum value, and the probability of excess (P) is calculated by assuming a relatively low discharge exceeding 92% (with a corresponding discharge of 12 Mm3/year or Q92% = .50 m3/s) for the WEAP input in the Awash sub-basin of the Borkena Basin only. This area should not be overlooked, using the weak concepts of flow analysis shown in Table 7 and Figure 8.

Table 7. Flow duration curve of Borkena River at swamp outlet Near Kemiessie

Month	Q (Mm^3/YEAR)	FRANK(M)	N+1	P=100(M/N+1)	
Aug	1443	1	13	8%	30
Sep	663	2	13	15%	30
Jul	651	3	13	23%	30
Oct	335	4	13	31%	30
Mar	226	5	13	38%	30
Jan	223	6	13	46%	30
Apr	200	7	13	54%	30
May	196	8	13	62%	30
Dec	192	9	13	69%	30
Nov	178	10	13	77%	30
Feb	177	11	13	85%	30
Jun	142	12	13	92%	30

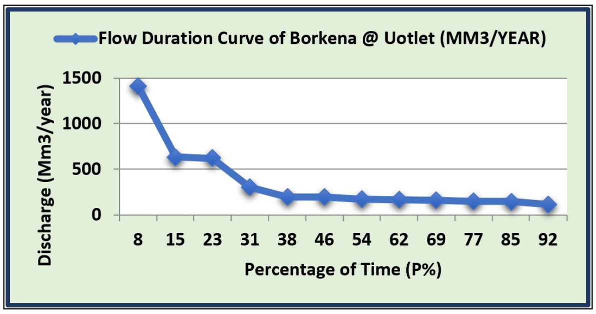


Figure 8. Flow Duration Curve for minimum Environmental Flow Requirement

3.4. Modeling of Water Demand for all scenarios

3.4.1. Current Scenario

The model current account was developed using demand data from 2019 and the Kemiessie store flow (supply) simulation data is 553. Mm3. The study area has at least six consumer needs, urban water demand, rural water demand, agriculture, livestock, industrial waste,r demand, and baseline water demand. Table 8: summary of model results for the current account (water consumption). These results indicate that utilization is low relative to the population in the flooded Kombolcha sub-basin. The total current water consumption in the study area is estimated at 390. 7 MCM per year. Thus, the amount of water extracted in the flooded Kombolcha sub-basin represents about 70.6% of the total available water in the region, or 553. Mm^3 per year. By comparing water requirements with available surface water resources, in the flooded Kombolcha sub-basin only 70.6% of the water available in the area is available for consumption. This scenario achieves an entire project-specific (2019), current data for the entire period with no changes imposed, and serves as a point of comparison for other scenarios where changes are performed for system data

Table 8. Average monthly Water Consumption of all demand node current accounts (Mm^3)

Month	AWD	CIWD	IWD	LWD	RWD	UWD	EFR	Sum
	1,1326ha	-	-	1,610,161	1,190,255	544,111	-	-
19-Jan	0.2	0	0.34	6.29	1.1	1.69	5.30	14.92
19-Feb	0.49	0	0.3	5.68	0.99	1.52	4.13	13.11
19-Mar	0.49	0	0.34	6.29	1.1	1.69	6.02	15.93
19-Apr	0.26	0	0.32	6.09	1.06	1.63	0.19	9.55
19-May	0.23	0	0.34	6.29	1.1	1.69	3.18	12.83
19-Jun	0	0	0.32	6.09	1.06	1.63	0.05	9.15
19-Jul	0	0	0.34	6.29	1.1	1.69	52.88	62.30
19-Aug	0	0	0.34	6.29	1.1	1.69	111.67	121.09
19-Sep	0.04	0	0.32	6.09	1.06	1.63	62.67	71.81
19-Oct	0.29	0	0.34	6.29	1.1	1.69	27.08	36.79
19-Nov	0.31	0	0.32	6.09	1.06	1.63	3.21	12.62
19-Dec	0.32	0	0.34	6.29	1.1	1.69	0.63	10.37
Sum	2.63	0	3.96	74.07	12.93	19.87	277.01	390.47

3.4.1.1. Unmet demand, demand coverage, and demand reliability for Current-scenarios

This study considered unmet demand, coverage, and demand reliability. Unmet demand is the amount of unmet requirements for each demand location and coverage is from 0% (no water) delivered to 100% (full requirement delivery). Reliability is a measure of how often or likely a system is in a satisfactory condition that meets certain criteria.

A) Unmet demand, demand for Current-scenarios (2019)

Unmet demand is defined as the amount of water that cannot be physically supplied from a river during a particular period of the year. This situation can be exacerbated in the future due to increased demand for water if no action is taken. Simulations using WEAP show requirements for April-June and November-December. As shown in figures 9 a) and b), a channel map similar to the case where rainfall occurs in the second half of the season, peak runoff occurs from July to October, and runoff is still fairly low from April to June and November to December. So it's difficult to achieve them which is shown in Figures 9 a) and b).

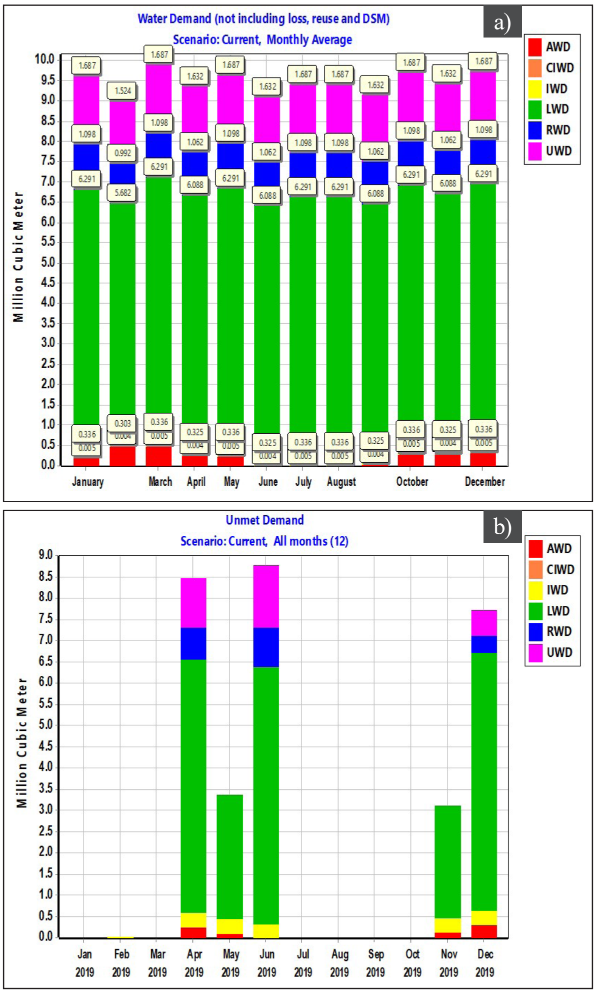


Figure 9. a) Current Monthly average water demand of all sectors in demand node b) Current Monthly average unmet demand of all nodes

B) Demand site coverage (%) for Current-scenarios (2019)

In the case of all Sectors in demand nodes are note covered 100% except July to October. While the other month over the year notes fully covered example from April to June average percent of coverage is 31.07% (unmet demand, 20.7 Mm^3) and from November to December percent of coverage is 42.7% (unmet demand, 10.8Mm3) which is the total unmet demand 20.7+10.8 = 31.46, this variation is clearly shown in the study area based on the result from WEAP model. Here, seasonal variations of rainfall lead to varying flow from each catchment in the study area as shown in Figure 9.

C) Demand site Reliability (2019)

The demand reliability in the current -Scenario for all demand sites does not reach 100% because available surface water is highly dependent on precipitation so this precipitation variation under the study area leads to demand reliability or dependability on available surface water is decreased. The demand reliability of all demand sites is shown in table 9.

Table 9. Demand site Reliable percentage for current -Scenario

Demand site Reliable Reference Scenario	AWD	CIWD	IWD	LWD	RWD	UWD
Percent (%)	62.50	55.56	54.17	55.56	75.00	75.00

3.4.2 Reference Scenario (20202030-)

Reference Scenario (2020-2030) represents the changes that are likely to occur in the future without intervention in new policy measures; it only increases with population growth. The population growth rate is 4.7% for urban and 1.3 rural% and for livestock is an average of 0.7 % annually. While assuming that similar trends of the streamflow situation will exist in the future. Hydrological conditions, Industrial and commercial, and institutional water demand are assumed unchanged into the future in this scenario. Climate change scenarios and their impact on surface water resources in this study are hard to be taken into account due to the limitations of climate data as shown in Table 10.

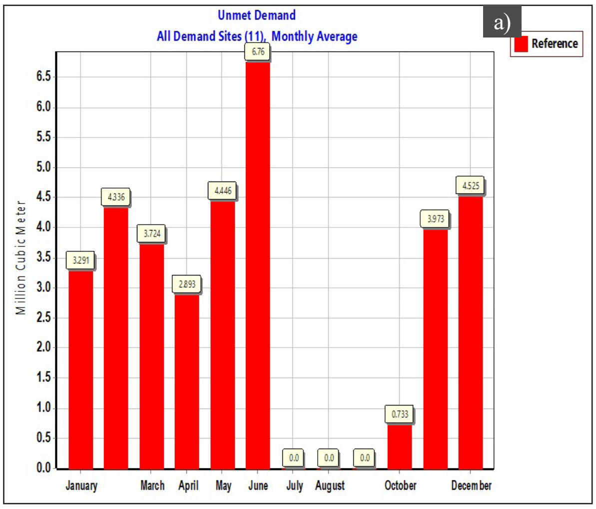
Table 10. Water Consumption (MCM) of the Reference Scenarios 2020_2030

Year	AWD	CIWD	IWD	LWD	RWD	UWD	EFR	Sum
2020	2.77	0.05	4.1	74.07	13.09	20.12	13.01	127.21
2021	2.94	0.05	4.25	74.07	13.26	20.38	8.53	123.48
2022	3.12	0.05	4.4	74.07	13.44	20.64	13.09	128.81
2023	3.33	0.05	4.56	74.07	13.61	20.91	10.17	126.7
2024	3.55	0.05	4.73	74.07	13.79	21.18	8.4	125.77
2025	3.8	0.05	4.9	74.07	13.97	21.46	5.36	123.61
2026	4.07	0.05	5.07	74.07	14.15	21.74	39.77	158.92
2027	4.37	0.05	5.26	74.07	14.33	22.02	89.57	209.67
2028	4.7	0.05	5.45	74.07	14.52	22.31	40.15	161.25
2029	5.07	0.05	5.65	74.07	14.71	22.6	13.57	135.72
2030	5.47	0.05	5.85	74.07	14.9	22.89	5.43	128.66
Sum	43.19	0.55	54.22	814.77	153.77	236.25	247.05	1549.8

The analysis of the result shows that there is not a significant change in the demand within the area when comparing this reference scenario with the scenario of the current account and is around 8.7 % of the total surface water availability in the study area. Therefore, there is a significant increase in livestock, rural and urban demand, due to the population in this area highly depending on livestock.

3.4.2.1. Unmet Demand and Demand coverage in Reference Scenario (20202030-)

The simulation with WEAP suggests that the unmet demand for this scenario shows significant change when comparing the current account, the requirements for Jan to June, and November to December. Still, the change followed similar to hydrographs during the rainy season that has a peak flow in July to November with flows higher shortage in the month Jan to June and November to December with the corresponding value of total demand coverage (%) and demands unmet is 46.52% of coverage and unmet demand 384.7 MCM as shown in Figure 10.



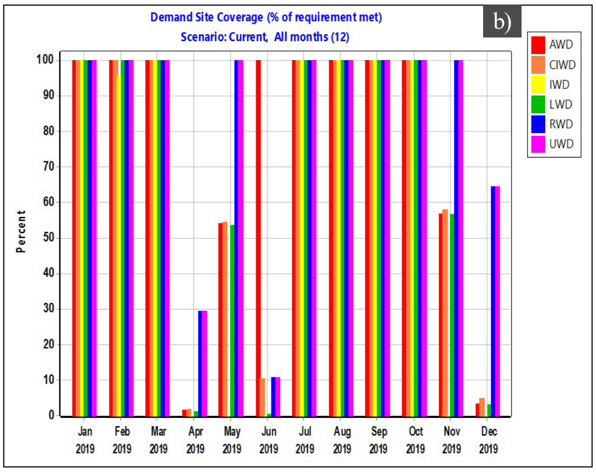


Figure 10. a) All Demand site coverage in (%) current scenario b) Unmet Demand for all nodes in Reference Scenario (2020-2030)

3.4.3. Medium growth up to 2030

Assuming a general medium growth scenario for 2030, where again livestock populations are increased by 1,610,161 to 1,776,937 with the corresponding value of average growth rate of 0.7% annual water used to be 81.9Mm^3. This means the annual water use rate is 90.5% increment shown when we compared the current scenario. The population rate in the study area has grown to almost a 5% annual increase from 544,111 to 930,615 and a 1.8% annual increase by 1,190,255 to 1448323 for urban and rural respectively (in 2030). Environmental flow demands stay constant (annually 247.05 Mm^3 for the Borkena River) as given in Table 11.

Table 11. Water demand of all demand nodes based on medium scenarios

Year	AWD	CIWD	IWD	LWD	RWD	UWD	EFR	Sum
2020	2.93	0.05	4.11	75.41	13.4	21.89	13.01	130.8
2021	3.3	0.05	4.28	76.77	13.88	24.14	8.53	130.95
2022	3.73	0.06	4.45	78.16	14.39	26.61	13.09	140.49
2023	4.24	0.06	4.63	79.57	14.91	29.34	10.17	142.92
2024	4.83	0.06	4.82	81.01	15.45	32.35	8.4	146.92
2025	5.52	0.06	5.01	82.47	16.01	35.66	5.36	150.09
2026	6.33	0.06	5.22	83.97	16.59	39.32	39.77	191.26
2027	7.3	0.06	5.43	85.48	17.2	43.35	89.57	248.39
2028	8.45	0.07	5.65	87.03	17.82	47.79	40.15	206.96
2029	9.81	0.07	5.87	88.6	18.47	52.69	13.57	189.08
2030	11.43	0.07	6.11	90.21	19.14	58.09	5.43	190.48
Sum	67.87	0.67	55.58	908.68	177.26	411.23	247.05	1868.34

It must be highlighted at this point again, that there are extremely trends of demand in livestock development and hence assumes quite high-water demand and has envisioned correspondingly high absolute abstractions from the rivers, these at some point might surpass the available river flows in this scenario for the Borkena river for instance in the total water demands of 1868.34Mm^3 have been abstracted from the total annual streamflow of 4625 Mm^3, and 2757 Mm^3 is reaming to the river.

3.4.3.1. Unmet Demand for Medium Growth Up To 2030

The unmet water demand is much higher in this scenario, the dry season demands and supplies are not balanced, however, the analysis shows that the situation of the unmet water demand monthly has been selected (Jan to June) and (Oct to Dec). Average monthly projections for river flows were selected as the highest unmet water demand in June. The result in this scenario shows that still considering the flow at the Kemiessie outlet of gauge station, the unmet demand during June is hence projected as 64.4Mm3 for Borkena River. The total unmet water demand is 515.2 Mm^3 corresponding to its demand coverage of 38.8%. Due to the agricultural, population, and livestock developments and demand variation on monthly flow are achieved in the medium growth scenario. Hence the dry season water demand is relatively high as compared with the rainy season. But extending the Socio-economic development in these scenarios with the increasing agricultural, industrial, commercial, and institutional development as result the remaining surface water availability above in 4.4.3 will be sufficient based on wet seasons but in dry months over the year demand is greater than the supply due to the available water resource is highly dependent on seasonal rainfall as shown in Figure 11.

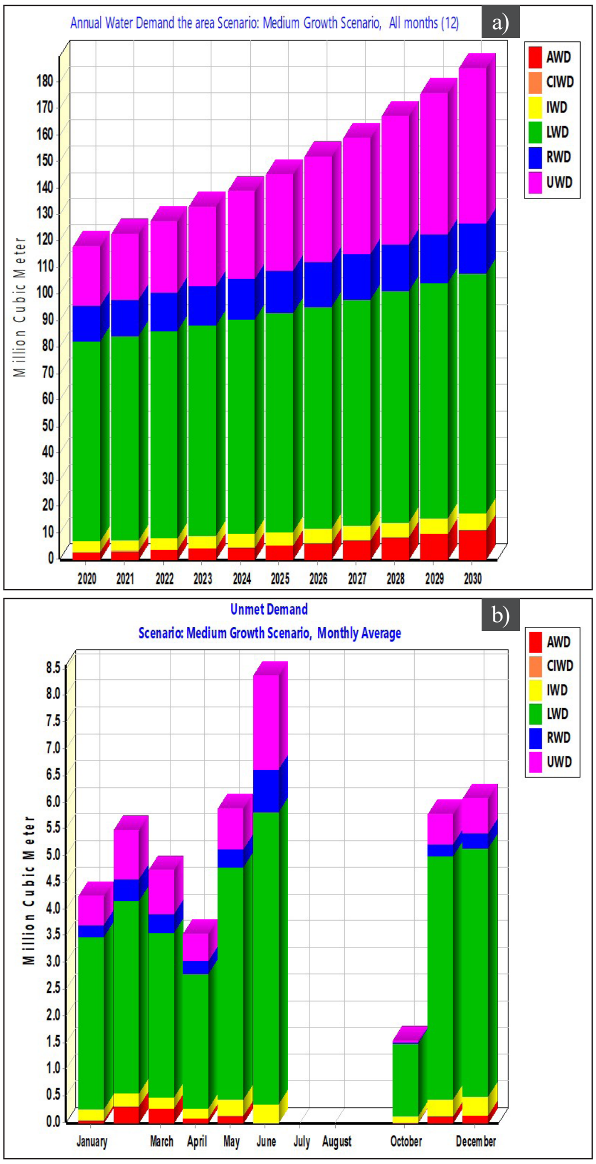


Figure 11. a) Water demand of all demand nodes based on medium scenarios b) Unmet water demand based on medium scenarios

In the flooded Kombolcha catchment of Volkena, urban, rural, livestock, and agricultural water demand account for about 33.86% of total surface water availability, while industrial and commercial water demand accounts for about 1.22 of water demand. About 32.4% of the total average annual demand in the study area is highest in the months (January-June) and (October-December). The medium-growth scenario shown in Figure 12 shows a tendency to increase faster than the base value. This is highly dependent on local precipitation, which will significantly reduce the availability of water in the future, impacting economic and environmental conditions. And its surrounding area catchment area is shown in Figure 12.

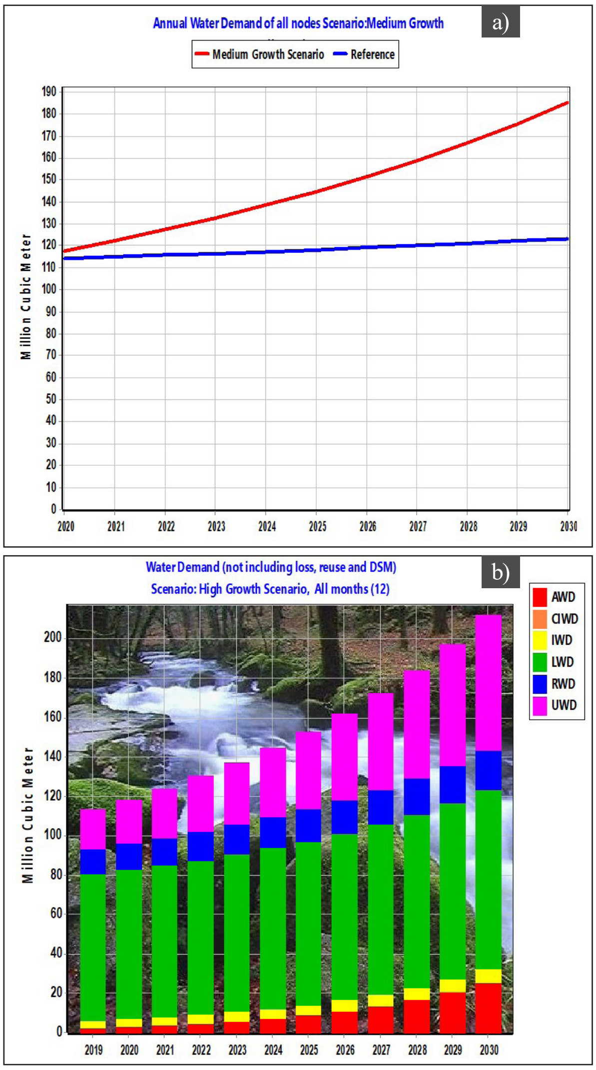


Figure 12. Comparison of Annual water demand for all nodes between medium growth and reference Scenario b) all scenarios in annual water demand

3.4.4 High growths up to 2030

The result in this scenario also shows that still considering the flow at the Kemiessie outlet of gauge station, the unmet demand during June is hence projected as 68.8Mm3for Borkena River, and the total unmet water demand is 572.6 Mm^3 corresponding to its demand coverage of 30.9%, due to the population density and large livestock size extremely expose in a surface water shortage for the other socio-economic developments scenario except for rainy season tables 12,13, 14 and Figure 13.

Table 12. Water demand of all demand nodes based on High scenarios

In (Mm3)	AWD	LWD	RWD	UWD	CIWD	IWD	EFR	Total
Annual Activity	35,450ha	1,786,648	1,479,933	1,011,649	-	-	-	
Water demand	122.86	914.26	181.75	457.58	0.66	59.2	247.05	1983.3MCM
Unmet demand	572.6Mm^3							

Table 13. Comparison of water demand, unmet demand, and coverage

All Scenario	(Total Available surface water resource (MCM) 2019-2030)) = 4625 MCM	water used from Available (MCM)	Available water remaining Storage (MCM)	Unmet demand (MCM) Observed during (Jan to June) & (Oct to Dec)	Demand Coverage (%) Observed during (Jan to June) & (Oct to Dec)
Current account by 2019	544.5	390.5	154	31.5	73.77
Reference 2020-2030	4080.3	1549.81	2530.49	384.7	46.52
Medium Growth up to 2030	4080.3	1868.35	2211.95	515.2	38.8
High Growth up to 2030	4080.3	1983.32	2096.98	572.6	30.9

Table 14. Comparison of water demand for all scenarios

All Demand site	current data by 2019	Reference scenario up to 2030	Medium Growth up to 2030	High Growth up to 2030
AWD	2.62	43.19	67.87	122.82
CIWD	0.05	0.59	0.66	0.66
IWD	3.95	54.21	55.58	59.20
LWD	74.07	814.74	908.68	914.26
RWD	12.93	153.77	177.25	181.75
UWD	19.86	236.25	411.25	457.58
EFR	277.00	247.05	247.05	247.05
Sum	390.48	1549.81	1868.35	1983.32

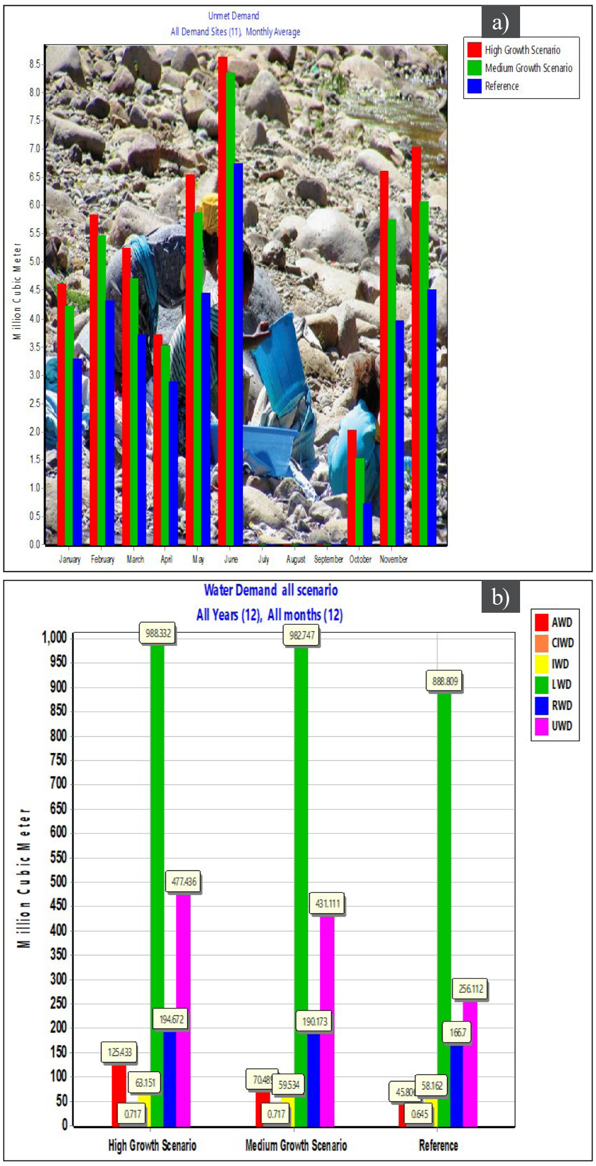


Figure 13. Unmet Demand of all Scenarios in the study area b) summary of total water demand by 2030 scenarios

3.5. Water resource and optional adaptation measures

Ethiopia is currently experiencing significant natural and socio-economic changes that are changing the availability and needs of water resources. Due to its geography and climate, Ethiopia has always been characterized by high hydrological variability. It was exacerbated by the almost complete lack of reservoirs and highly sensitive watersheds (Beatrice et al., 2015). Climate change is expected to increase uncertainty and extremes in meteorological patterns and increase precipitation variability (Beatrice et al., 2015). In addition, the remarkable economic growth and population growth of the last decade require a lot of good water resources, causing known pollution problems. Nevertheless, Ethiopia's water sector is still characterized by poorly integrated plans, and the allocation of water resources is not based on competing demands or a systematic understanding of water availability. This has already led to conflicts, as shown in the case of the Awash River basin between upstream, middle, and downstream water users (Beatrice et al., 2015). WRM's existing legal and political framework has already fixed the basic principles of Integrated Water Resources Management (IWRM). But; needs updates and enhancements. Also, catchment plans by the Embryonic River Basin Authority (AWRBA) remain weak. The establishment of a "sufficient" institution (WRM) in Ethiopia is hampered by a lack of knowledge about resource conditions, usage patterns, and the impetus for change. Lack of on-site capacity and skills to plan water distribution and assess impact. Etc. (Beatrice et al., 2015).

Agricultural demand comprises irrigation of large plots and formal schemes. Therefore, only scaled irrigation is represented in this sector. Within the WEAP model, the irrigation water demand varied inter-annually or monthly based on rainfall. During wet years the irrigation demand reduces and during dry years it increases (Pousa,2019). Agricultural irrigation demands have been calculated by simulating the demand node on WEAP and the CropWat8 model of the Food and Agriculture Organization (FAO) was used to simulate the observed seasonal pattern of irrigation with different cropping seasons in the area. Metrological data were used to estimate net evaporation (ETo), Kc and effective rainfall from the study area, and monthly share of irrigation demand.

3.5.1 Scenarios adaptation measures

Table 14 and Figure 13 above show that the region's only demand coverage (%) for all sectors is monthly (7), as precipitation in this region is characterized by a rainy season / long bimodal precipitation pattern. It indicates that it will be filled from month to September), which means less / shorter rainy season. The low/short rain months from March to April cannot meet the demands of all sectors, even if the environmental flow requirements of the study area are required. Precipitation patterns such as October, November, December, January, February, May, and June are dry. For this reason, other optional implants such as rainwater harvesting are needed surface water harvesting to meet the peak demand for dry months where the availability of surface water resources in these scenarios is felt in all waters. And use the sector where you need to book groundwater together. However, this combination of surface and groundwater may improve and address problems related to water scarcity (January-June) and (November-December), satisfying demand and efficient use. Groundwater nourishes the surface, although it should be considered an important strategy. Water needs to be improved and used for catchment management through integrated large-scale management. The results of this study clearly show that in all scenarios there is an oversupply on the supply side during the rainy season in the sub-collection area, and an integrated approach to water resource development in the sub-collection area is taken. To avoid the use of water in the dry season, it is necessary to meet the water demand of all sectors and respond to competition and conflict. Sub-basin water resources required great demand for current water resources in the morning, such as the Jara River and wetlands, to properly manage water. This supply-side surplus must also be secured during the rainy season throughout the year to meet future water demand if harvested carefully. One of the main objectives of this study is to assess the availability of surface water in terms of supply and demand systems in the Awash-Kombolcha sub-basin of the Bokanea River. The result of this study is to transfer supply and demand forecasts up to 2030 to assess the possible impacts of future scenarios related to surface water availability. Stakeholders and civil society participation in water management and conservation efforts need to be facilitated through education and capacity building, making policy processes more transparent and collaborative. Suggested that integrated river basin management is included as an important element of an efficient and effective strategy to address water scarcity, especially in dry months, through the use of increasingly scarce resources in the study area. It's an exaggeration to do. It provides a wide range of opportunities for all stakeholders, including the general public, to share their views and influence results. Raise awareness at the basin level and develop various preventive and mitigation measures against floods and droughts. Build consensus and public support for results. Build stakeholder involvement. Ensuring flood management plans for river basins with extensive public support. Ensure the sustainability of plans and related decisions. Strengthen the resilience of flood-prone communities.

4. Conclusion

The overall purpose of the study is to perform surface water availability and demand analysis for water resource planning in the flooded Kombolcha catchment of the Bokanea catchment. This has been elaborated by using the WEAP approach (water assessment and planning tool). It was that. Based on the results of the survey, the following conclusions were drawn. The availability of surface water sub-basin is (544.5 Mm3 emissions), and under current water demand conditions, pet and livestock water demand, the average annual emissions at the Samp Exit measurement station near Khemiessy are. It is 17.3 m3 / s. 106.9 million m3 is the largest consumer of surface water, followed by agriculture, trade, industry, and 6.6 million m3, with an environmental requirement of 142 million m3. Currently, the total annual water demand in the basin accounts for 20.85% of the total surface water available, which is sufficient to meet the site's total water demand during the rainy season. Analysis and simulation of surface water availability and demand in the flooded Kombolcha sub-basin of the Bokanea River have limited data availability through the basic functions of WEAP, without the use of a link between groundwater analysis and climate change. It was executed. In this study, a scoring model was used to operate on the WEAP underwater catchment scale and monthly time steps. The survey period was 2019-2030. The calculation of evaluation model was performed by calculating the overall model of the reference scenario, which is a failure scenario, generated using the current account information for the study period (2019-2030). The year of the current account is selected as the base year for the valuation model. In this survey, all current account data are relevant for 2019. The adaptation methods regarding water harvesting and flood control can be achieved by providing all stakeholders, including the public, with full opportunities to share their views & influence the outcome; raising awareness at the basin level & developing a host of preventive & mitigation measures against floods & droughts. Build consensus & public support for the outcomes; build stakeholders' commitment; ensure implementation of basin flood management plans with full public support; ensure the sustainability of plans & associated decisions, and build the resilience of flood-prone communities.

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Acronyms

AWD Agricultural water demand
CIWD Commercial and institutional water demand
EFR Environmental flow requirement
IWD Industrial water demand
LWD Livestock water demand
RWD Rural water demand
UWD Urban water demand

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