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DETERMINATION OF SEASONAL CHANGE IN WATER LEVEL OF GUBI DAM FOR SUSTAINABLE URBAN DEVELOPMENT

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Abstract
Gubi Dam is one of the largest dam located in Bauchi state and it serves as the major source of drinking water for the entire Bauchi metropolis. Due to the high level of water consumption ranging from domestics, industrial and agricultural use, there exist significant changes in seasonal water level in the dam as a result of meteorological and climatic variables. During reconnaissance, water levels and rainfall data was collected from Bauchi State Water Corporation whereas the hydrological and meteorological data was collected from NIMET office of Bauchi state. Gubi reservoir water level elevations and changes from 2015 to 2021 were examined using Landsat data 8. The water source in the dam varies in quantity and quality due to the seasonal variation over the catchments area. During rainy season, from the period of May to October, the quantity of water in the reservoir will increase due to the amount of the rainfall observed during these periods. During dry season the level of water reduced due to high consumption and the effect of evaporation due to high temperature, the peak value of evaporation mostly occurred within the period of January to April and is the period of drought and high demand of water and it cause a drawdown of the reservoir water level. The results were analyzed, discussed and presented. The surface area of Gubi reservoir in March 2015 was 5224500m^2 and the mean of the dry season is 5988600 m^2. The seasonal variation in Gubi dam from the period of March 2015 and the mean was 764100 m^2. This shows that the dam has accommodated more water in 2015 than the mean of the dry season. So invariably it implies that Gubi reservoir level rise in 2015 during dry season, around March 2015 increase in water level. It is recommended other researcher to conduct research on hydrological modeling of Gubi reservoir to investigate the impacts of the reservoirs in water resources management.

KEYWORDS: *Seasonal change, Water level, climatic variables, reservoirs and water resources*

Background of the Study

Gubi Dam is one of largest dam located within Bauchi local government area of Bauchi state and its serves as the major source of drinking water for the entire Bauchi metropolis. Due to the high level of water consumption ranging from domestics, industrial and agricultural use, there exist significant changes in seasonal water level in the dam as a result of meteorological and climatic variables. These variables may include seasonal rainfall, temperature (maximum & average) wind and radiation flux. Generally, whenever a dam is constructed along a river channel, the riparian communities around such locations are often affected directly or indirectly since; human activities are subject to changes. The dam was constructed purposely to supply water to the entire Bauchi Metropolis and its adjoining environment.

The source of water in Gubi dam is mainly coming from three tributaries, namely Gubi River, Tagwaye river link with Shadawanka and Ran River. The function of the dam is to supply the state capital and its environs with potable water. A temporary dam close to the site was constructed across one of the stream to provide water needed for the construction of the permanent dam. The embankment of the dam which has length of 3.86km and bottom earth-fill of 2,315, 000m^3 with a reservoir area of 590 hectares. The catchments area is 17,900 hectares with total storage capacity of 38.4 x 106 m^3, the expected yield from the reservoir is 90,000m^3/d (Bauchi State Water Board, 1981). The dam was started with temporary structures, which was constructed across one of the streams at the permanent dam site to provide water needed for the construction of the permanent dam. In this temporary dam about 500 million gallons of water which is equivalent to be impounded, while the construction of the permanent dam was going on it was decided to make use of the temporary dam to supplement the water supply to the town (Abdullahi, 2014). Change detection is the process of identifying the differences in the state of an object or matter or phenomenon by observing it at different times (Singh, 1989). There are varieties of digital change detection techniques which have been developed, such as mono-temporal change delineation, delta or post classification comparisons, multi-dimensional temporal feature space analysis, composite analysis, image differencing, multi temporal linear data transformation, change vector analysis, Distance Tree Classification (DTC), image regression, background subtraction and image rationing (Nori et al, 2005). Throughout the past decades, the change detection process was useful in many applications and researches that related to change detection such as landscape and habitat fragmentation (Munroe et al, 2005; Nagendra et al, 2006).

The basic purpose of impounding reservoir is to hold runoff during period of high runoff, and release it during period of low runoff; the specific functions of reservoir are hydroelectric flood control, irrigation, water supply and recreation. Many large reservoirs are multipurpose. The use of reservoir for temporarily storing stream flow often results in a net loss of total stream flow due to evaporation and seepage. While these losses may not be desired the benefits derived from regulation of water supplies from flood water storage, from hydroelectric power and from any recreational activities at the reservoir site may offset the hydrologic losses and the cost of reservoir storage capacity can be divided among three (3) major uses:- (i) The active storage used stream flow regulation and for water supply. (ii) The dead storage required for sediment collection, recreational development hydropower production. (iii) The flood storage capacity reservoir to reduce potential downstream flood damage in the design of storage reservoir to serve as a water supply system for any community, it has been further recommended that judgment be based on the equalizing or operating storage which can be read from a demand curve during 12 and 24 hours respectively. Evaporation from lakes more especially from impounded reservoirs, where it may reduce the yield from a catchments area by a considerable amount, the amount lost depend upon temperature of the air and water, wind, velocity, and atmospheric humidity. The high evaporation loss from reservoir in arid region has stimulated experiment in methods of reducing it by application of thin chemical film floating cover, or floating granular materials. None of these technique have proved to be practical in large-scale application but are useful on small reservoir Steel and Terence, (1972).

The hydrological cycles of major lakes and rivers are of great importance for studies of local response on regional and global climate change. Lake level and temporal change can reflect water mass balance of a basin, and is closely related with climate parameters of precipitation, temperature, evaporation, humidity, wind, etc. Lake level variations also affect bottom sediment characteristics, ecological consequences, circulation pattern, and wind-driven waves. Lake level data, one of the most important and fundamental datasets used in hydrologic analysis, are traditionally obtained through gauge measurements. However, in many cases, limited spatial distribution of hydrological gauges is often not able to provide adequate or continuous observations due to economic and political reasons. There is even a decrease of globally gauging networks during the last decade. Many studies show that satellite radar and/or laser altimetry provide effective and powerful data for many potential applications in oceans, rivers, lakes, wetlands, and floodplains Medina (2010).

Rivers are the major water resources that accumulated to form dams. Water qualities of rivers tend to getting worse because of pollutants from surrounding watersheds (Bae, 2017). In addition, changes of flow rate of rivers between rainy season and dry season could bring difficulties to maintain river's water quality (Kim 2008). River's water quality might be affected by various factors. Among them, non-point source pollutants are the main concern for river's water quality management and rainfall events play a very important role as carriers for non-point source pollutants moving to the water body (Bae, 2017). The purpose of dam management is to efficiency put in place criteria leading the purpose of the dam as well as safety procedures. The dam should be planned considering other projects or river facilities in its river basin to demonstrate its purpose effectively. Furthermore, it is necessary to execute the investigation carefully from the early stage so as not to generate stagnation or retreat because the dam is large-scale and needed much cost for construction. Because the appearance of the dam reservoir exerts a big influence on the environment, the mitigation or conservation should be considered to decrease the influence as much as possible. As the dam reservoir is forming by damming of the existing river, the management and operation of the dam should be carried out safely and properly unlike other facilities. In addition, the dams are operated for a long period of time in proper condition, so the countermeasure for the sedimentation is important for the longevity of dam reservoir.

There is even a decrease of globally gauging networks during the last decade. Many studies show that satellite radar and/or laser altimetry provide effective and powerful data for many potential applications in oceans, rivers, lakes, wetlands, and floodplains. Water surface changes are studied with high precision ICESat (the ice, cloud, and land elevation satellite) altimetry data (Guoqing, 2014).

Water supply issues are creating unprecedented pressures because of increasing population and economic demands. As irrigated agriculture represents 70% of global water consumption, managing water resources is a major concern in maintaining sustainable agricultural practices. Water management will become even more relevant in the future as urbanization, industrialization, and climate change exert greater pressures on water use (OECD, 2012). Water resources can be monitored on a global scale using three approaches: in situ measurements, modelling, and remote-sensing observations (Jorgensen et al., 2005; Harding and Warnaars, 2011; Hall et al., 2011; Duan and Bastiaanssen, 2013).

Singh and Gupta (2016), Observations and modeling of terrestrial water cycle is important for sustainable management of water resources as well as understanding the impact of climate change. Satellites provide an important role in measurements of various dimensions of water cycle components in spatio-temporal domain. Paper reviews the scientific basis and techniques of retrieval of various hydro-meteorological parameters (Rainfall, Soil Moisture, Evapo-transpiration, Groundwater, Water level, Surface Runoff, conjunctive water utilization and Water quality etc.) which are estimated using advanced satellite based instruments (Altimeter, Radar, Optical and Microwave Radiometers). Variability of various hydro-meteorological parameters and recent satellite based observation on flood and hydrological drought condition in selected regions over India is discussed.

Nagaraj et al (2015), water reservoirs are the main source of water supply for many settlements as well as power generation. So the water volume and extent of the reservoirs needs to be monitored at regular time intervals for efficient usage as well as to avoid disasters like extreme rainfall events and flood etc. Generally the reservoirs are remotely located so it is difficult to well monitor the water volume and extent. But with growing of Remote sensing and GIS in HPC environment and modeling techniques it is possible to monitor, estimate even predict the reservoir water volumes in advance by using the numerical modeling and satellite Remote sensing data. In this work the monitoring and estimation of the volume of water in the Krishna Raja Sagar (KRS) water reservoir in Karnataka state of India. In this work multispectral images from different sources like Landsat TRS and Digital Elevation Model (DEM) using IRS LISS III (IRS-Indian Remote Sensing, LISS- Linear Imaging Self-Scanning) and ASTER (Advanced Space borne Thermal Emission and Reflectance Radiometer) are being used .The methodology involves GIS and image processing techniques such as mosaicking and georeferencing the raw data from satellite, identifying the reservoir water level, segmentation of water body using the pixel level analysis. Calculating area and depth per each pixel, the total water volume calculations are done based on the empirical model developed using the past validated data. The water spreaded area calculated by using water indexing is converted in to vector polygon using ArcGIS tools. Water volume obtained by this method is compared with ground based observed values of a reservoir and the comparison well matches for 80% of cases.

Baup (2014), this study presents an approach to determining the volume of water in small lakes (<100 ha) by combining satellite altimetry data and high-resolution (HR) images. In spite of the strong interest in monitoring surface water resources on a small scale using radar altimetry and satellite imagery, no information is available about the limits of the remote-sensing technologies for small lakes mainly used for irrigation purposes.

Cochrane et al (2014), the rapid rate of water infrastructure development in the Mekong Basin is a cause for concern due to its potential impact on fisheries and downstream natural ecosystems. In this paper, we analyze the historical water levels of the Mekong River and Tonle Sap system by comparing pre- and post-1991 daily observations from six stations along the Mekong mainstream from Chiang Saen (northern Thailand), to Stung Treng (Cambodia), and the PrekKdam station on the Tonle Sap River. Observed alterations in water level patterns along the Mekong are linked to temporal and spatial trends in water infrastructure development from 1960 to 2010. We argue that variations in historical climatic factors are important, but they are not the main cause of observed changes in key hydrological indicators related to ecosystem productivity. Our analysis shows that the development of mainstream dams in the upper Mekong Basin in the post-1991 period may have resulted in a modest increase of 30-day minimum levels (C17 %), but significant increases in fall rates (C42 %) and the number of water level fluctuations (C75 %) observed in Chiang Saen. This effect diminishes downstream until it becomes negligible at Mukdahan (northeast Thailand), which represents a drainage area of over 50% of the total Mekong Basin. Further downstream at Pakse (southern Laos), alterations to the number of fluctuations and rise rate became strongly significant after 1991. The observed alterations slowly decrease downstream, but modified rise rates, fall rates, and dry season water levels were still quantifiable and significant as far as PrekKdam.

Chih-Hua et al (2015),Surface water quality has been identified as potentially vulnerable to climate change. This study assesses the impacts of climate change on the water quality of Hsinshan Reservoir, Taiwan, through CE-QUAL-W2 simulations. The model parameters were calibrated by field data collected during 2004–2008, and verified against observations made during 2009–2012. The projected temperature and precipitation data for the near- and long-term future were downscaled to regional and daily scales, and used to simulate the projected changes in water quality through the validated model. The simulation results were reported as probability-based cumulative distribution functions to access the impacts of climate change on water quality. The results indicated that the intensified thermal stratification caused by the rising temperature is the primary driver of water quality decline, which increases the probability of deep-layer oxygen depletion and the flux of limiting nutrients for algae growth, resulting in a higher risk of algal blooms and eutrophication. The adaptation strategies of multilevel-intake operations and increasing bottom-layer dissolved oxygen without destratification are recommended.

Statement of the Problem

Bauchi metropolis has witnessed remarkable expansion since its inception of Bauchi state in 1967. This has therefore lead to an increase in water consumption in Bauchi metropolis. The consumption of large volume of water which resulted in changes in water level from its water sources (Gubi dam). And also, this change in water level causes flooding to submerge the neighboring villages. The effect of this flooding resulted so many problems within Bauchi metropolis such as insufficient portable drinking water, shortage of water for industrial use, and also agricultural use. Water, and alterations in the status of her change in water level over time without any detailed and comprehensive attempt (as provided by a Remote Sensing data and GIS) to evaluate this status as it changes over time with a view to detecting the water consumption rate and also make attempt to predict same and the possible changes that may occur in the water level. The research will use remote sensing/GIS techniques to evaluate variation in water level of Gubi Dam.

Aim and Objectives

The aim of this research is to determine seasonal change in water level of Gubi dam and its relationship with Rainfall, Temperature and Wind flow using remote sensing techniques. The aim of the research will be achieved through the following objectives

i. Mapping changes in water level of Gubi Dam using remotely sensed data and GIS techniques
ii. Determining the trend and patterns in seasonal rainfall, temperature and wind flow.
iii. Determining the relationship between the parameter of objective one and two above

Scope of the Study

The scope of this research is restricted to Gubi Dam area in Bauchi state of Nigeria. The work comprises of field reconnaissance, data acquisition, georeferencing, image processing, image enhancement, geometric correction, data integration and supervised classification.

Justification for the Study

Indeed, attempt has been made to document the growth of Gubi Dam in the past by conventional means. The dynamics in the change of population size and density of Bauchi metropolis has change the pattern and trend of water consumption for both domestic and industrial use. This has led to the shortage of water within Bauchi metropolis, inherently affecting water quality. The research would be useful for water resource planning and management, hydrological drought studies, flood forecast and pollution studies.

The Study Area

Bauchi metropolis lies between latitude 09^{o}52^{1} and 09^{o}56^{1}North of the Equator and longitude 10^{o} 45^{I} and 10^{o} 45^{I} East of the Prime Meridian (Fig. 1). The study area is located in Bauchi Local government area is located on the north-eastern edge of the Jos plateau. Bauchi state was derived from Bauchi town. It covers a total land area of 3,687 square kilometers, and a population of 493,810, according to the 2006 population census. It is the most populous part of the state, as it serves as the seat of the state government. This increase in population, coupled with the socio-economic activities in the metropolis has implications for solid waste generation, disposal and management in the area (Nigeria population commission).

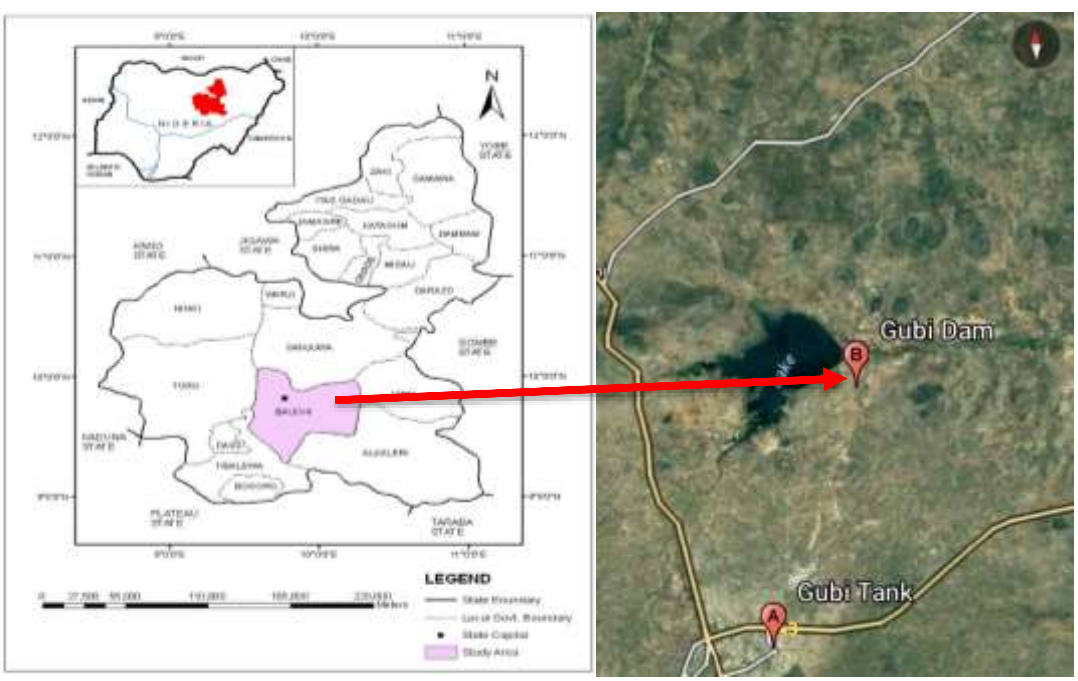


Figure 1 Map of Study Area

Materials and Methods

The methodology adopted for acquiring complete datasets for precise representation is divided into two stages namely: data acquisition and data processing. The former deals with the data collection while the latter focused on data manipulation and processing. Satellite images of the study area were downloaded for ten (10) different years for both drying and raining season. DGPS receiver was used to determine the coordinates of the points used for geo-referencing the satellite images. The downloaded satellite images were imported into ArcGIS environment and georeferenced. Image enhancement and geometric correction were carried out to improve the quality of the satellite images. The attribute data was also collected from which Bauchi State Water Corporation and NIMET office of Bauchi State; the data includes water levels, rainfall data and hydrological, meteorological data respectively. Statistical analysis was carried out on the attribute data and the results area presented.

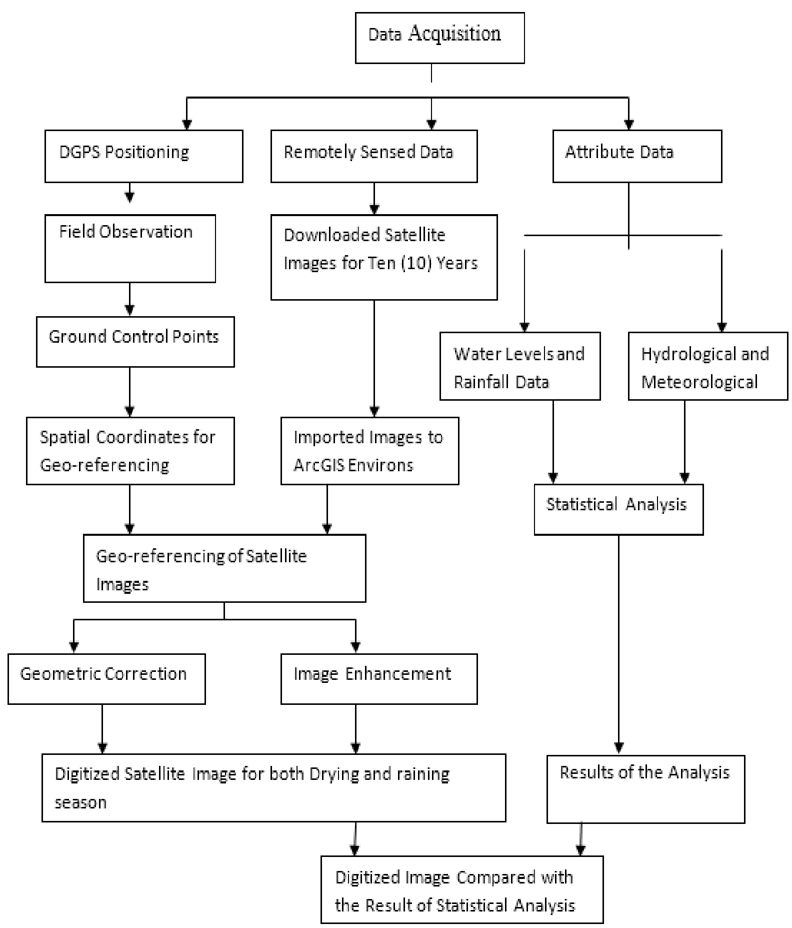
Equipment Used

The equipment needed for the research work are as follows:

DGPS receiver and its accessories, Computer and its accessories for processing and analysis, ArcGIS 10.3 software, Microsoft Office word 2007 and SPSS Software for statistical analysis

Working Chart of the Methodology

The flowchart used for data acquisition, data processing and analysis is presented in figure 2 as indicated beside:



Reconnaissance

During reconnaissance, water levels and rainfall data was collected from Bauchi State Water Corporation whereas the hydrological and meteorological data was collected from NIMET office of Bauchi State. The study area was visited to have an overall picture and to acquaint with the nature of the study area for the purpose of ground truthing and planning of field work. During this exercise various land use land cover and dam facilities were visited and compare with Landsat images in order to reconcile between the features on the ground and image. Inaccessible areas such impounded reservoir and some of forest were viewed from Google map image. The coordinates of identified location on the images were captured for geo-referencing.

Data Used

The data used in this study are Landsat 7 and 8, map of the study area, water levels, and rainfall data, hydrological and meteorological data.

Remotely Sense Data

Considerable effort was put into selecting cloud-free data sets and to get data near the same date and the same season in order to reduce seasonal difference effects on the images. Landsat 8 satellite images of the study area. The selected images were acquired between November and April and July and October which is considered as dry and rainy season in the study area because there are no available imageries to maintain consistency in day but seasonal consistency was maintained. These images were downloaded from the United State Geological Survey (www.earthexplorer.usgs.gov).

Ground Control Points

The coordinates of prominent locations were observed with DPGS which was used for georeferencing the satellite images. During the field survey, 6 Ground Control Points (GCP) were collected for the purposes of ground truthing. These GCPs were captured from distinct features on the images such as road junctions, buildings, and much other landscape feature identifiable clearly on the satellite images. The Points were used for the minimization of geometric distortion of the images by georeferencing with ArcGIS Software. This was also used to unify the coordinate system of all the Satellite Images downloaded. The coordinates used for geo-referencing is as showed in Table 3.3.

Table 1: Coordinates used for Geo-referencing

S/No	EASTING (M)	NORTHING (M)
1	590272.076	1149941.615
2	590347.560	1149587.566
3	590630.023	1147949.555
4	590823.989	1147613.867

5	591265.472	1147062.609
6	591395.051	1146527.667

Documented Data: Hydrological and Meteorological Data

The water levels and rainfall data in the reservoir was collected from Bauchi State Water Board Corporation located in Gubi while the hydrological and Meteorological data, Temperature, Wind and Radiation flux was collected from the NIMET Bauchi State Centre.

The sample of the attribute data is showed in Table 2.

GUBI DAM WATER LEVEL RECORD

S/N	DATE	TIME	RECORD (MSL)
1	1-6-2010	8:30	554.245
2	2-6-2010	8:40	554.232
3	3-6-2010	8:54	554.220
4	4-6-2010	9:13	554.208
5	7-6-2010	8:55	554.179
6	8-6-2010	9:23	554.167
7	9-6-2010	8:34	554.155
8	10-6-2010	8:45	554.152
9	11-6-2010	9:34	554.140

Table 3: Sample of the Attribute Data

JULY 2006

S/N	Temperature		Rainfall	Wind
	Maximum	Minimum		
1	31.0	24.0	TR	2
2	32.0	25.0		3
3	32.0	24.0	32.2	3
4	35.0	23.0	36.4	3
5	34.0	24.0	26.6	4
6	31.0	22.0	32.2	4
7	29.0	24.0	36.4	2
8	33.0	23.0	32.2	2
9	31.0	22.0	36.4	2
10	34.0	24.0	25.6	3

Data Integration

The main purpose of data integration is to allow data from different sources to be referenced in the same spatial domain so that this data can be effectively overlaid with other data for further analysis. Since data from different sources may use different map projections, there is a need for their conversion into a standard and common map projection. However, this task was performed with utmost attention to overcome data been inaccurately geo-referenced, which can result in spatial inconsistency among different data sources even though the same map projection is utilized. Data integration in this research started from the pre-processing stage where all satellite images and map were geo-referenced to a common coordinate system. The UTM Zone 32 WGS84) datum was select. SPSS (Software Package for Social Science) version 15 was used to analyzed the correlation between the change in water level and surface area of the reservoir, water level and temperature, water level and wind, water level and Radiation and Surface area of the reservoir and temperature respectively.

Analysis and Presentation of Results

Analysis of Map of Gubi Reservoir in 2014

The images of the Gubi reservoir as at March and July 2014 are showed in Figure 4.1 and Figure 4.2 respectively. The surface area of Gubi reservoir in March 2014 is 536.928 hectares whereas in July 2014 is 693.856 hectares. The seasonal variation in Gubi dam from the period of March 2014 to July 2014 is 156.928 hectares. This shows that the dam accommodates more water in July 2014 than in March 2014. The Gubi reservoir level in rainy season begin to rises up to a maximum value of 556.895 m especially in the period of November 2014, whereas in the period of December to around March 2014 decreased to minimum of 553.226m as a result of water required by the community and in addition most likely due to wind, temperature and radiation flux.

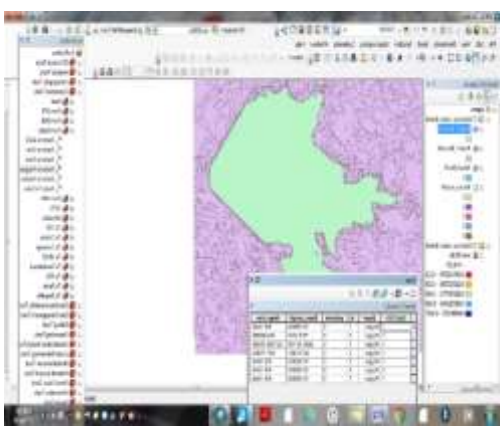


Fig. 3: Map of Gubi Reservoir (01 March,2014)

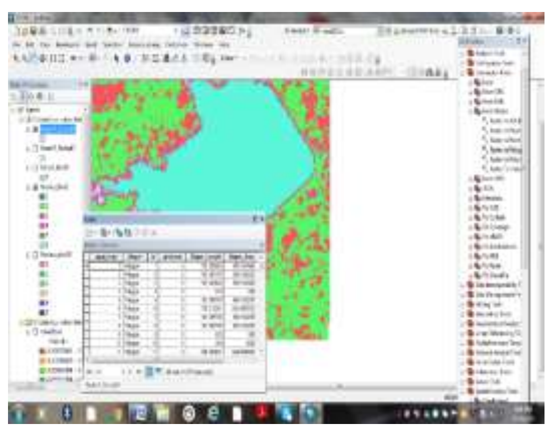


Fig. 4: Map of Gubi Reservoir (31 July,2014)

Analysis of Map of Gubi Reservoir in 2015

The images of the Gubi reservoir as at March and July 2015 are showed in Figure 4.3 and Figure 4.18 respectively. The surface area of Gubi reservoir in March 2015 is 585.570

hectares whereas in July 2015 is 631.802 hectares. The seasonal variation in Gubi dam from the period of March 2015 to July 2015 is 46.232 hectares. This shows that the dam accommodates more water in July 2015 than in March 2015. The Gubi reservoir level in rainy season begin to rises up to a maximum value of 556.982m especially in the period of November 2015, whereas in the period of December to around March 2015 decreased to minimum of 554.030m as a result of water required by the community and in addition most likely due to wind, temperature and radiation flux.

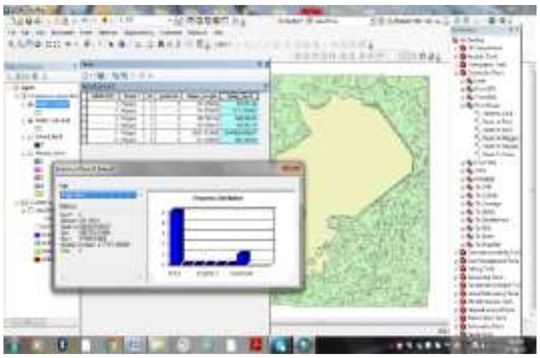


Fig. 5: Map of Gubi Reservoir (12 March,2015)

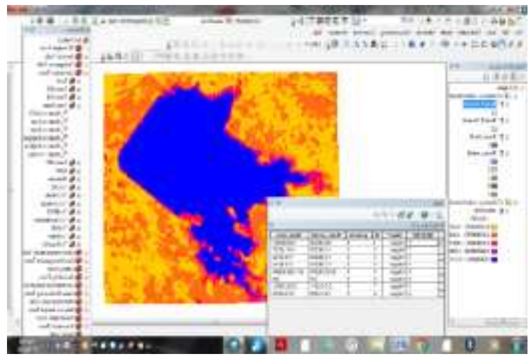


Fig. 6: Map of Gubi Reservoir (02 July, 2015)

Analysis of Map of Gubi Reservoir in 2015

The images of the Gubi reservoir as at January and July 2016 are showed in Figure 4.5 and Figure 4.6 respectively. The surface area of Gubi reservoir in January 2015 is 596.235 hectares whereas in July 2016 is 681.257 hectares. The seasonal variation in Gubi dam from the period of January 2016 to July 2015 is 85.022 hectares. This shows that the dam accommodates more water in July 2016 than in January 2016. The Gubi reservoir level in rainy season begin to rises up to a maximum value of 557.848m especially in the period of November 2016, whereas in the period of December to around March 2016 decreased to minimum of 554.674m as a result of water required by the community and in addition most likely due to wind, temperature and radiation flux.

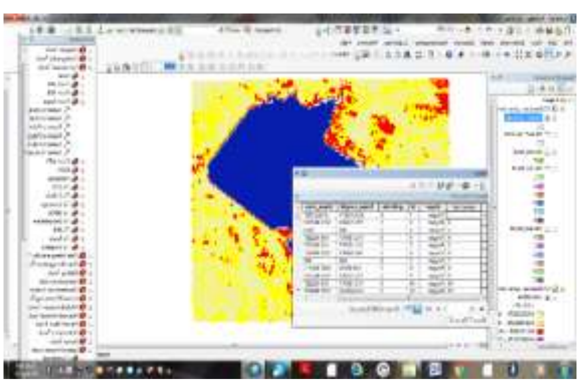


Fig. 7: Map of Gubi Reservoir (09 January, 2016)

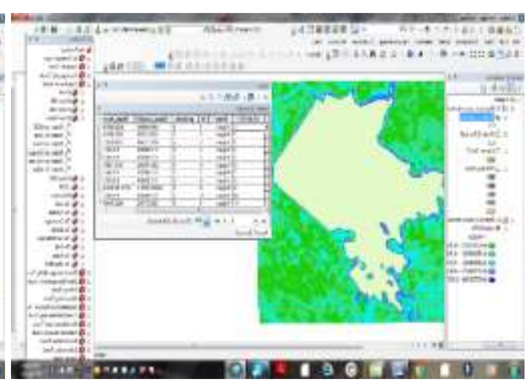


Fig. 8: Map of Gubi Reservoir (04 July, 2016)

Analysis of Map of Gubi Reservoir in 2017

The images of the Gubi reservoir as at January and July 2017 are showed in Figure 4.7 and Figure 4.8 respectively. The surface area of Gubi reservoir in January 2017 is 514.965 hectares whereas in July 2017 is 622.675 hectares. The seasonal variation in Gubi dam from the period of January 2017 to July 2016 is 107.710 hectares. This shows that the dam accommodates more water in July 2017 than in January 2017. The Gubi reservoir level in rainy season begin to rises up to a maximum value of 557.954m especially in the period of November 2017, whereas in the period of December to around March 2017 decreased to minimum of 555.262m as a result of water required by the community and in addition most likely due to wind, temperature and radiation flux.

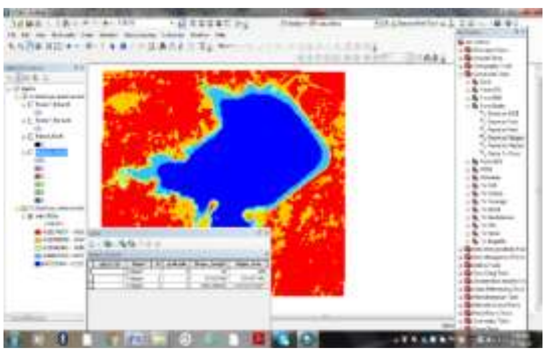


Fig. 9: Map of Gubi Reservoir (09 Jan,2017)

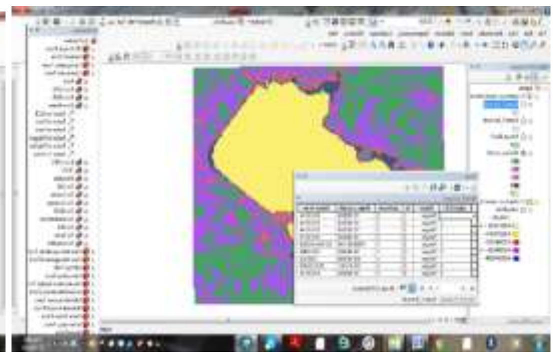


Fig. 10: Map of Gubi Reservoir (07 July, 2018)

Analysis of Map of Gubi Reservoir in 2018

The images of the Gubi reservoir as at January and July 2018 are showed in Figure 4.9 and Figure 4.10 respectively. The surface area of Gubi reservoir in January 2018 is 614.641 hectares whereas in July 2018 is 673.724 hectares. The seasonal variation in Gubi dam from the period of January 2018 to July 2018 is 59.043 hectares. This shows that the dam accommodates more water in July 2018 than in January 2018. The Gubi reservoir level in rainy season begin to rises up to a maximum value of 557.954m especially in the period of November 2019, whereas in the period of December to around March 2018 decreased to minimum of 555.262m as a result of water required by the community and in addition most likely due to wind, temperature and radiation flux.

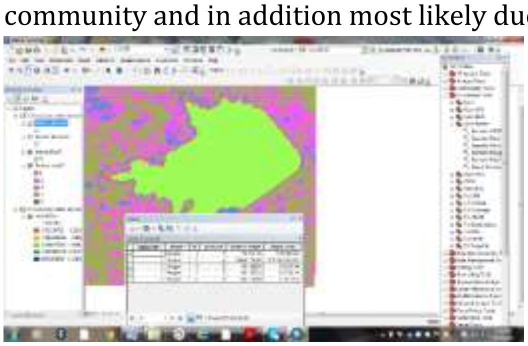


Fig. 11: Map of Gubi Reservoir (07 July, 2019)

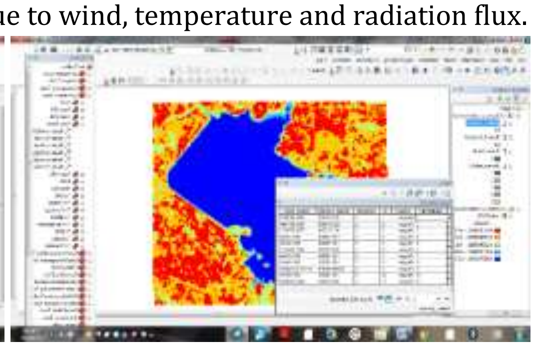


Fig. 12: Map of Gubi Reservoir (07 July, 2019)

Analysis of Map of Gubi Reservoir in 2019

The images of the Gubi reservoir as at January and July 2019 are showed in Figure 4.11 and Figure 4.12 respectively. The surface area of Gubi reservoir in January 2019 is 626.791 hectares whereas in July 2018 is 684.789 hectares. The seasonal variation in Gubi dam from the period of January 2019 to July 2019 is 57.999 hectares. This shows that the dam accommodates more water in July 2019 than in January 2019. The Gubi reservoir level in rainy season begin to rises up to a maximum value of 557.954m especially in the period of November 2019, whereas in the period of December to around March 2019 decreased to minimum of 555.262m as a result of water required by the community and in addition most likely due to wind, temperature and radiation flux.

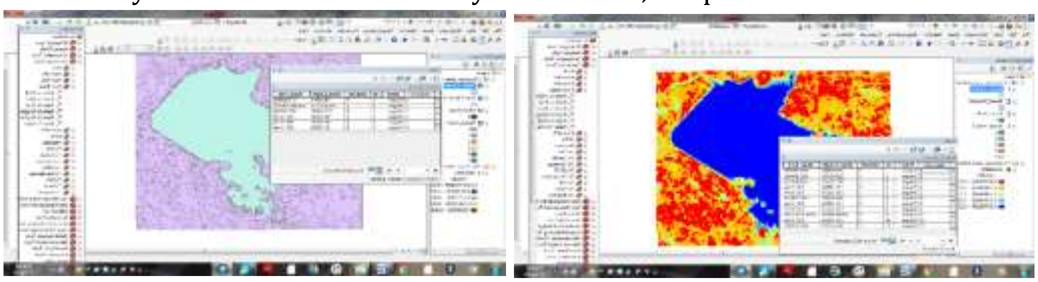


Fig. 13: Map of Gubi Reservoir (07 July, 2019)

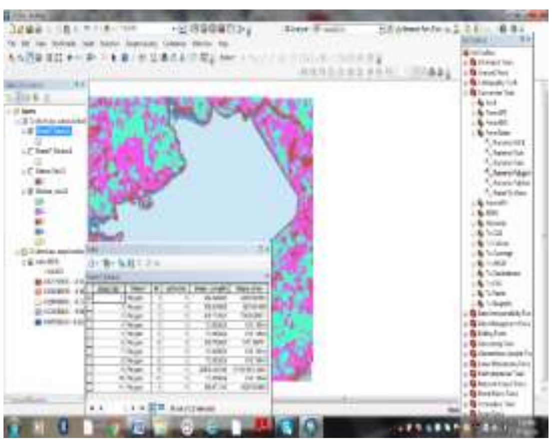


Fig. 14: Map of Gubi Reservoir (07 July, 2021)

Analysis of Map of Gubi Reservoir in 2021

The averages reduce level, surface area of the Gubi reservoir and the climatic variables are showed in Table 4.1. Plate 4.1 is the profile of the climatological Variables which indicated the variations between wind, temperature and radiation flux. Plate 4.2 showed the profile of the surface area of the Gubi reservoir and the average reduce level for each year. The higher the temperature, the higher the rate of evaporation in every year, therefore reduces the volume of the water in the reservoir.

Table 4: Sample of Climatologically Variables

Years	Days	Area (Hectare)	Aver. RL (m)	Diff in area(Hec)	Max-Tem (m)	Min-Tem (m)	Radiation	Wind
2019	12-Mar	625	554.030		30.6	20.2	23	2
	2-Jul	671	556.982	46	35.2	18.2	21	2
2020	9-Jan	648	554.674		24.5	12.2	25	4
	4-Jul	699	557.848	51	31.1	20.3	12	2
2021	7-Jul	694	557.954		32.5	17.9	16	3

	9-Jan	649	555.262	45	33.8	22.8	23	3

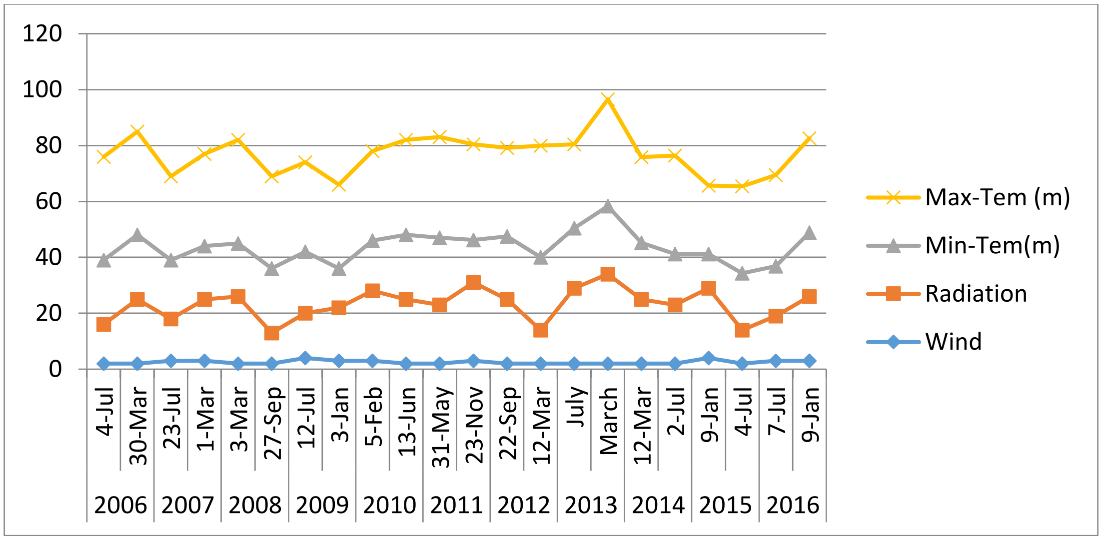


Plate 1: Climatologically Variables

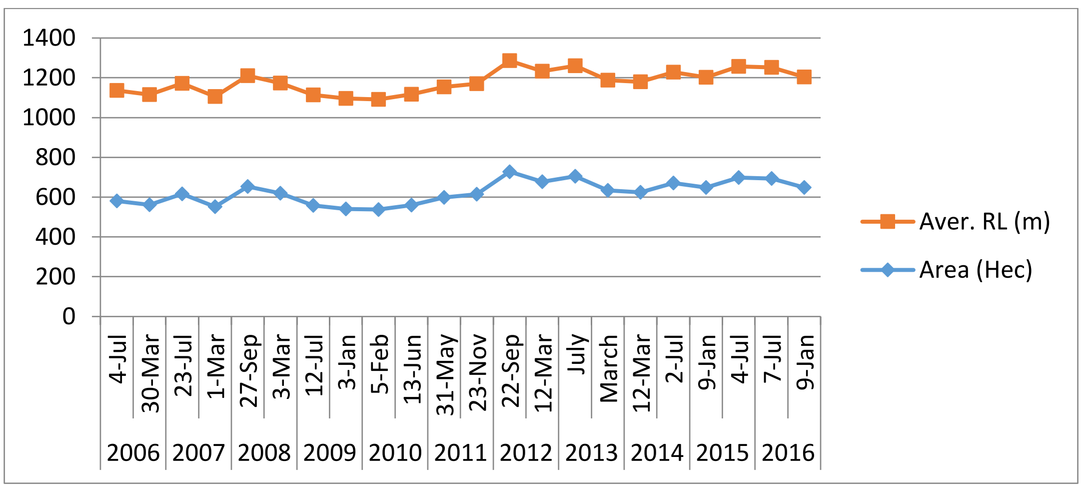


Plate 2: Profile of the Surface Area Covered and Average Reduce Level from 2014 to 2021

Summary

The LandSat imagery of the Gubi reservoir were downloaded from 2014 to 2021 and used for the analysis. The surface area of Gubi reservoir around January to April and November to December decreased drastically whereas in the period of May to October the surface area increased maximally. The seasonal variation in Gubi dam from the period of 2014 to 2021 varied increasingly due sedimentations from tributaries. The temperature and radiation flux has great influence on the volume of water in the reservoir whereas wind has little influence on the volume of water in the reservoir. The Gubi reservoir level in rainy season begin to rises up to a maximum level while in the period of December to around March of each year the reservoir level decrease as a result of water required by the community and in addition most likely due to wind, temperature and radiation flux. The profile of the climatological Variables which indicated the variations between wind, temperature and radiation flux were plotted. The results showed that the higher the temperature, the higher the rate of evaporation in every year, therefore reduces the volume of the water in the reservoir.

Conclusion

In this study, Gubi reservoir water level elevations and changes from 2014 to 2021 are examined using Landsat data. The water source in the dam varies in quantity and quality due to the seasonal variation over the catchments area. During rainy season, from the period of May to October, the quantity of water in the reservoir will increase due to the amount of the rainfall observed during these periods. During dry season the level of water is reduced due to high consumption and the effect of evaporation due to high temperature, The peak valve of evaporation is mostly occur within the period of January to April and is the period of drought and high demand of water and it's may cause a drawdown of the reservoir water level.

Recommendations

i. We recommend that managers of Gubi dam should be able to predict the likelihood of floods with the available data and hence putting in place remedial actions to ensure that the community is not at risk.
ii. We recommend other researcher to conduct research on hydrological modeling of Gubi reservoir to investigate the impacts of the reservoirs in water resources management.
iii. We've also recommended further study on assessment of evaporation rates and sediment yield in Gubi reservoirs as this has a significant effect in water levels

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