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EFFECTS OF SOME WEATHER PARAMETERS ON RICE AND TOMATO PRODUCTION IN THE DOWNSTREAM OF TIGA STATION, NIGERIA

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Abstract

This study investigates the effects of some weather parameters on rice and tomato production in the Tiga station downstream. Data on rainfall, temperature, evaporation and reservoir water level data for 30 years and 24 years rice and tomato yields were used. The data collected were analyzed using the relative definition method and Pearson's Product Moment Correlation Coefficient. A focus group discussion was conducted to get first-hand information from the farmers. The Relative Definition Method (RDM) showed the rainfall onset, retreat periods and the length of the growing season for the station downstream. The RDM revealed the first decadal of May with cumulative percentage rainfall values of 7.94% for the onset, while the retreat period was the first decadal of October with a cumulative percentage rainfall value of 92.56%. The Pearson's product-moment correlation between climatic variables (rainfall, temperature evaporation) and reservoir water level at Tiga station revealed that only rainfall in Tiga with 0.98 showed a very strong positive significant relationship on the reservoir water level in the study. Similarly, only rainfall showed a strong positive significant relationship between climatic variables and crop yields. The r-value between rainfall amount, rice and tomato production in Tiga station downstream were 0.94 and 0.90 respectively. These showed positive significant relationships between rainfall and these crops implying that an increase in rainfall will lead to an increase in the amount of water available downstream for irrigation farming of rice and tomato and hence, good yields. Temperature and evaporation showed weak relationships on crop yields and positive insignificant relationships on the reservoir water level in the station downstream. Findings from the focus group revealed that 80% of the farmers reported flood occurrences during the rainy season and deficit of water in the latter days of the dry period (mostly between January and March of each year) which might be a result of operational failures(poor storage facilities) in the reservoir station. It was recommended that special projects and strategies should be adopted to address the issue of water deficit during the dry season and overflowing of the reservoir stations during rainy seasons to control surplus and deficit water inflow and outflow in all seasons as well as limits flooding, destruction of cultivated crops, arable lands and properties.

Keywords: Relative definition method, Correlation, Rice, Tomato, Tiga Dam

Introduction

Intergovernmental Panel on Climate Change (IPCC, 2007) defines climate change as a change in the state of the climate that can be identified by using statistical tests by changes in the mean or the variability of its properties which persists for an extended period typically decades or longer. Although the length of time it takes the changes to manifest matters, the level of deviation from the normal and its impacts on the ecology are most paramount.

Ayoade (2003) states that secular variations in climate occurring over 100 to 150 years may not qualify as a climate change if conditions will quickly reverse later, but a climate change usually takes place over a long period with clear and permanent impacts on the ecosystem. Climate change is different from the generally known terms like climatic fluctuations or climatic variability. These terms denote the inherently dynamic nature of climate on various temporal scales. Such temporal scale variations could be monthly, seasonal, annual, decadal, periodic, quasi-periodic or non-periodic. Bekoe and Logah (2013) defined weather as the state of the atmosphere at a particular place and time. In this study, the elements of climate and weather that are of interest are precipitation (rainfall), evaporation and temperature.

Rice and tomato are major consumed food crops in Africa whose cultivation could be affected by water scarcity, rainfall, evaporation and temperature. However, Irrigation is a major mitigation strategy to boost yields of these crops (Olaniyan, 2015). Nigeria is the African leading consumer of rice, and one of the largest producers of rice in the continent and simultaneously one of the largest rice importers in the world. Rice is an important food crop and essential cash crop. It is mainly cultivated by small-scale farmers who commonly sell 80 per cent of total production and consume only 20 per cent. It is mostly cultivated within a temperature range of 25 – 35°C, for good yields. Rice generates more income for Nigerian farmers than any other cash crop in the country (Olaniyan, 2015). Similarly, Nigeria was reported to be the second-largest producer of tomatoes in Africa after Egypt and 13th in the world, with a production of 6 million tons annually before 1990 (Idah, Ajisegiri and Jiya, 2007). Tomato is grown in Nigeria in its diverse agro-ecological zones that range from humid in the south to sub-humid in the middle belt and semi-arid and arid in the north. It is mostly cultivated within a temperature range of 25 – 34°C, for good yields (Idah et al.,2007).

Many researchers have examined floods, weather fluctuations, changes in climate, water resources and crop production in different parts of the country and the world at large, some of whose works include that of Ilyasu (2017) on flood risk assessment in parts of Hadejia-Jama'are River Basin (HJRB) of Jigawa State, Nigeria which assesses the level of socio-economic and environmental risks associated with the flood disaster in the study area for five years (2011-2015). The works of Abdullahi (2015) on the influence of weather parameters on the productivity of rice in the Kano River Irrigation Project used data on weather and rice yield for a period of 20 years (1994 – 2013). The works of Abdulrahaman and Sekyere (2017) on climate variability and sustainable food production in north-eastern Ghana investigated climate variability and its effect on the production of four specific food crops: maize, millet, rice, and groundnuts in north-eastern Ghana using data from six communities in the Upper East Region of Ghana.

The works of Olanrewaju, Tilakasiri, and Oso (2017) on climate change and rice production in Ekiti State explore the climatic effect on rice production using data obtained from the archive of the Nigerian Meteorological Station, Oshodi and rice data from Ekiti State Agricultural Development Project (A.D.P). The data covered the period of 5years between 2007 and 2011. Similarly the works of Olubanjo and Alade (2018) on the effect of climate variability on the yield of crops in Ondo State, Nigeria whose study assessed the effect of observed climatic variables (rainfall, temperature and relative humidity) on the yield of major crops, which are divided into two groups, tuber crops (cassava and yam) and fruits (pepper and tomatoes). All these studies strived to proffer solutions to address climatic challenges, floods and water shortages to boost crops yields. However, there seemed to be limited information on the effects of weather parameters on rice and tomato production simultaneously in Tiga station downstream as high rates of evaporation from the reservoir, persistent droughts, increased rainfall, faulty designs and operation of the multipurpose dams have often led to a drastic reduction of water availability and sometimes flooding of irrigated wetlands downstream. This, therefore, necessitates the need for findings to proffer a lasting solution to this challenging scenario.

The study aims to assess the effects of some weather parameters on rice and tomato production downstream of Tiga station and the objectives are to determine the onset and cessation of rainfall in the study area, examine the relationship between climatic variables (rainfall, temperature, evaporation) on water level and the relationship between climatic variables (rainfall, temperature, evaporation) on crop yields in the study area. The hypotheses statethat1) there is no significant relationship between climatic variables (rainfall, temperature, evaporation) and irrigation water resources in the study area;2) there is no significant relationship between climatic variables (rainfall, temperature, evaporation) and crop yields in the study area.

Study Area

The study area is Tiga dam located on Latitudes $11^{0}17'30''$N to $11^{0}28'00''$N and Longitudes $8^{0}20'0''$E to $8^{0}36'0''$E of Nigeria. The dam covers an area of 178 square kilometres with a maximum capacity of nearly 2000,000 cubic metres, with a potential irrigable area of about 45,300 hectares. The seasonal movement of the Intertropical Convergence Zone (ITCZ), which resulted in wet and dry seasons, influences the climate of the region. The area is characterized by a mono-modal rainfall distribution averaging 600 to 1300 mm per annum. The length of the growing period is 90 to 165 days (for rain-fed crops). Rainfall is strongly seasonal and occurs between April and October.

About 80% landmass of the study area is underlain by quartzite, undifferentiated metasediments and basement complex rocks of the Precambrian upper Cambrian origin while the soil is characterized into the Ferruginous Tropical Soils. The vegetation is categorized into Sudan and the Guinea savannah both having been replaced by secondary vegetation while the major natural rivers include River Challawa and River Kano. The population of Tiga station downstream is about 544,170 according to the 2006 population census, projected to 2018 at a 2.7% growth rate resulting in752,393**.** The economic activities of the people include farming, trading and fishing (Mustapha et al., 2014).

Methodology

A purposive sampling method was used to select Tiga station based on its downstream population and its irrigation farming activities while also considering the technology and industrial status of states in the study area. A survey of the study area was carried out to get the researcher acquainted with the study area and the data required for the study. The researcher visited the dam station and downstream on different days. The researcher was introduced to the facilities by the project manager who gave detailed accounts of how the station was been maintained especially with regards to readings of hydro metrological data, while at another time, the researcher visited the study area (downstream) to derive strategic modalities in carrying out the field investigations. A Focus Group Discussion (FGD) was carried out with the help of some local field assistants and some farmers to know the exact effects of these weather parameters and irrigation water resources on these crops productions. The types of data required for the study include Tiga station rainfall data from 1989-2018, Tiga station temperature data from 1989-2018, Tiga station evaporation data from 1989-2018, Tiga station reservoir water level data from 1989-2018 and crop yields data from 1994-2018. All data were obtained from the Tiga dam.

The Relative Definition Method (RDM) by Ilesanmi (1972) was used to determine the onset and cessation of rainfall in the study area. The first essential step of this method is to derive the percentage mean annual rainfall that occurs for each 5-day interval. This is followed by accumulating the percentages of the 5-day periods. When the cumulative percentage is plotted against time through the year, the first point of the maximum positive curvative graph

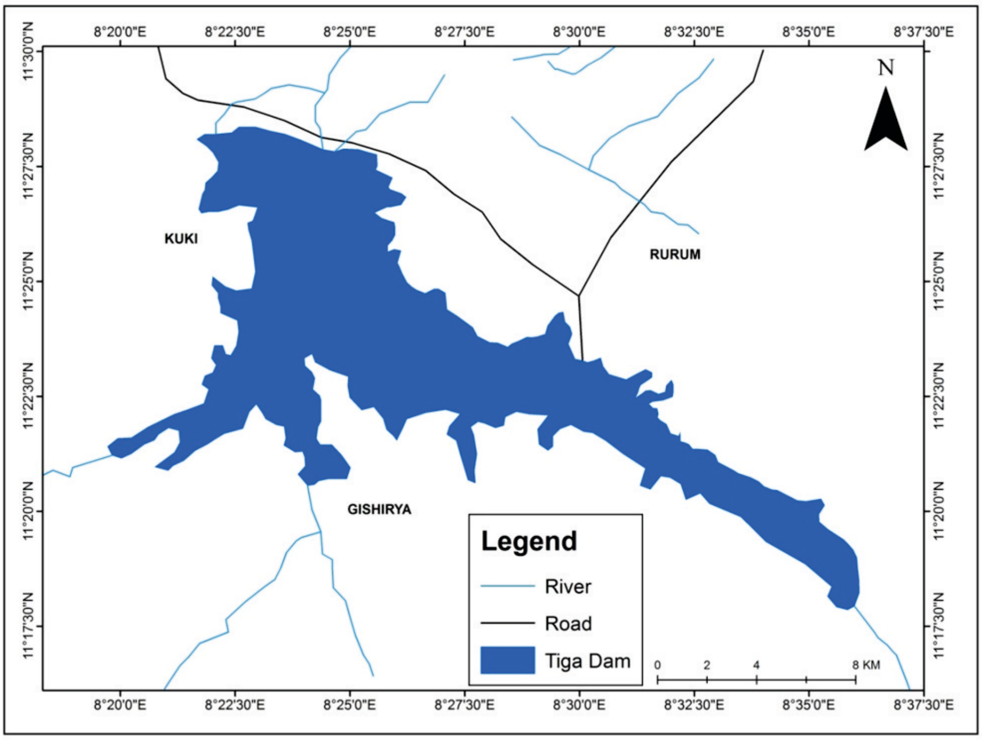

Figure 1: Tiga Dam
Source: Adapted from Google Imagery

corresponds to the time of rainfall onset, and the last point of maximum negative curvature corresponds to the rainfall cessation. Ilesanmi (1972) and Odekunle (2004) noted that the point of onset on the graph corresponds to the time when an accumulated 7–8% of the annual rainfall totals was obtained, whereas that of rainfall cessation is about 90%. The result was interpreted using Julian calendar.

The relationship between climatic variables (rainfall, temperature, evaporation) and water level in the reservoir and the relationship between climatic variables (rainfall, temperature, evaporation) and crop yields in the study area was achieved using the Persons Product Moment correlation co-efficient software package at 0.05 level of significance with the aid of (SPSS) version 20 software.

Results and Discussion

Findings from focus group discussion revealed that 80% of the farmers reported floods occurrences during the rainy season and deficit of water in the latter days of the dry period (mostly between January and March of each year) which might be a result of operational failures (poor storage facilities) in the reservoir station. The FGD also revealed that 83% of the farmers said they receive poor supports from the government. This finding is in agreement with the work of Ilyasu (2017) on flood risk assessment in parts of Hadejia-Jama'are River Basin (HJRB) of Jigawa State, Nigeria whose study revealed that heavy rainfall, inadequate drainage facilities and mismanagement of water reservoirs (mainly dams) are the major causes of the flood disaster. Also, Kaugama (2014) work on the prospect and challenges of farming along the Hadeja-Nguru Wetland in Jigawa State Nigeria also revealed the incidence of flooding. However, the work of Halliru (2015) on security implications of water shortages, climate change, farmers and cattle rearers in Northern Nigeria is not in agreement with the findings of this work as the study revealed that the destruction of crops and poor yields of crops usually arise from grazing and overgrazing of lands, unlike previously discussed works that attributed poor crop yields to heavy and increasing rainfall, rise or drops in temperature and flooding.

The rainfall data for the time frame of study (1989-2018) collected from Tiga station was used in line with the Relative Definition Method to show the onset and cessation of rainfall and length of the growing season. This was done to evaluate water level availability and crops growing season in the study area. Fig 2 shows the onset, cessation and length of growing seasons of rainfall in the Tiga dam station using the Relative Definition Method.

Figure 2 shows the rainfall onset, retreat periods and the length of the growing season in Tiga station downstream. The Relative Definition Method showed the period when 7–8% mean cumulative

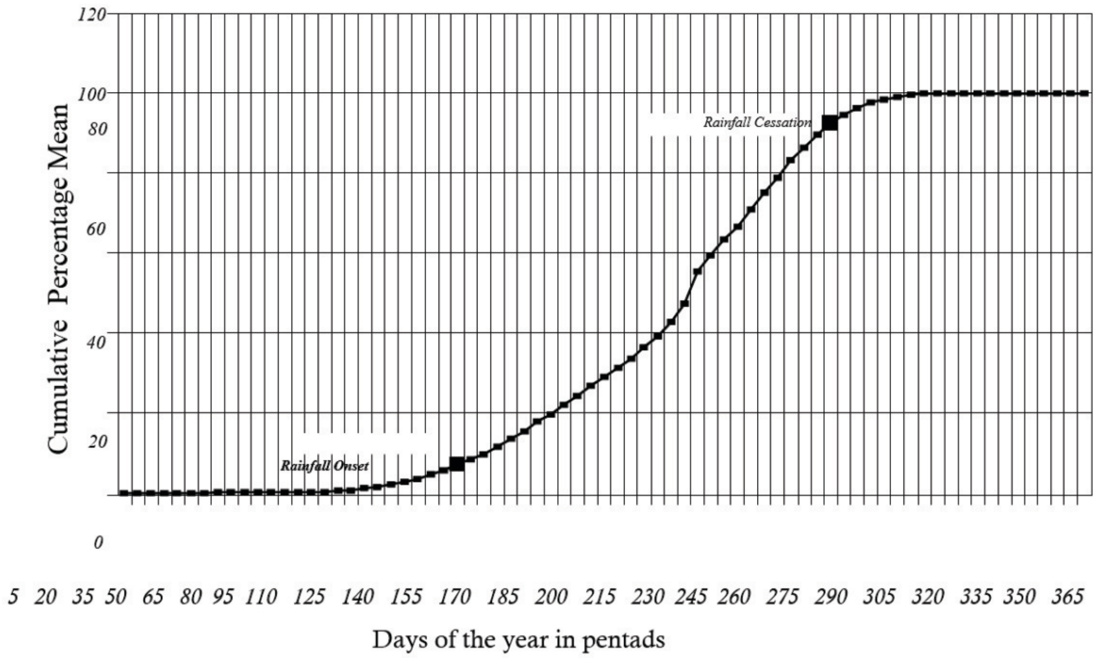

Figure 2: The onset, cessation and length of growing seasons of rainfall in Tiga dam stations using the relative definition method. Source: Authors' Analysis

rainfall of the 5-day periods is attained (corresponding to the time of rainfall onset). The corresponding periods for Tiga dam station as shown from the study, revealed the first decadal of May with cumulative percentage rainfall values of 7.94%, while the period of the year when over 90% of the mean cumulative rainfall for the 5-day periods is attained (corresponding to the time of rainfall retreat) was around first decadal of October with a cumulative percentage rainfall values of 92.56%.

The study revealed 4months for the mean length of the growing season for areas around the Tiga dam station. The study findings are similar to that of Odekunle (2004) on rainfall and the length of the growing season in Kano state whose study revealed a corresponding period of first decadal in June with cumulative percentage rainfall values of 9.28% for the onset and second decadal of September for cessation with a cumulative percentage value of 92.09%. However, its findings revealed three months mean length of the growing season. While another study onset, retreat and length of rainy days in Kaduna byOdekunle (2004) revealed the first decade of May for the onset with a cumulative percentage value of 7.14 and third decade of September for cessation with a cumulative percentage value of 92.56% and the length of the growing season was five months.

Relationship between Rainfall, Temperature, Evaporation and Water level in Tiga Dam Downstream.

The effect of rainfall, evaporation, temperature and water level was assessed using the Persons Product Moment correlation coefficient with SPSS version 20, software package at 0.05 level of significance and results presented in table 1.

Table 1: Relationship between Rainfall, Temperature, Evaporation, and Water Level in Tiga Dam

Variable	**Correlation(r)**
	Water level (Reservoir inflow)
Rainfall	0.98*
Temperature	0.55
Evaporation	0.53

*Significant at 0.05 level

Source: Authors' Analysis

Table 1 shows the correlation between rainfall, temperature, evaporation and water level in the Tiga station. The study revealed that the r value for rainfall is 0.98, while temperature and evaporation are 0.55 and 0.53 respectively. This shows a strong positive significant relationship between rainfall and water level in the area and a fairly positive but not strongly correlated relationship for temperature and evaporation. This implies that an increase in rainfall will lead to an increase in the amount of water in the reservoir and vice versa while temperature and evaporation do not seriously influence water level in the reservoir at a 0.05 level of significance. The findings of this study has similarities with that of Adegbehin, Yusuf and Iguisi (2016) on the effects of some weather parameters and reservoir inflow pattern on hydroelectric power generation in Kainji dam Niger state, Nigeria using 30years rainfall, evaporation, temperature and reservoir inflow data to investigate the trends and variability of these parameters and how it affects electricity generation. The study revealed the correlation between rainfall amount and power generated as 0.83 which implies a positive significant relationship between rainfall and power generated, which means that an increase in rainfall will lead to an increase in the amount of power generated and vice versa. However, the study noted that evaporation has no significant relationship with power generated at 0.05 level of significance as the correlation between them was 0.33. The study also revealed the r-value between temperature and power generated in the study area as 0.21. That implies that there is no significant relationship between the amount of power generated and temperature at 0.05 level of significance and changes in temperature does not lead to changes in the amount of power generated.

Lastly, the study revealed that reservoir inflow and power generated has a correlation of 0.92 and thus showed a significant positive relationship at a 0.05 level of significance. Meaning, that a change in reservoir inflow will affect the amount of power generated.

Similarly, the works of Chinda, Saraya and Uduma (2016) with the use of Pearson's Product Moment Correlation coefficient (r) showed a significant relationship between the annual rainfall totals and sorghum yields from 1996 to 2010. However, the study revealed that the coefficient was positive but not perfectly correlated with a value of +0.289.

The effect of rainfall, evaporation, the temperature on crop production was assessed in Tiga station downstream using the Persons Product Moment correlation coefficient with SPSS version 20, software package at 0.05 level of significance and results presented in Table 2.

Table 2 shows that the correlation (r) value between rainfall amount and rice production is 0.94 while that for tomato is 0.90. This shows a positive significant relationship between rainfall, rice and tomatoes which implies that an increase in rainfall will lead to an increase in the amount of water available downstream for irrigation farming of rice and tomatoes and vice versa, while the r-value between temperature, rice and tomato in the study area is 0.46 and 0.43 respectively, indicating a weak relationship between the variables which implies that there is no significant relationship between temperature, rice and tomato at 0.05 level of significance and changes in temperature does not lead significantly increase crop yields. Similarly, the "r" value for evaporation on rice and tomato is 0.37 and 0.34 respectively which also revealed a weak relationship between the variables implying that there is no significant relationship between evaporation, rice and tomatoes production at 0.05 level of significance in Tiga station downstream.

Table 2: Relationship Between Rainfall, Temperature, Evaporation, and Crop Yields in Tiga Dam Downstream

Variable	Correlation(r)	
	Rice	Tomatoes
Rainfall	0.94*	0.90*
Temperature	0.46	0.43
Evaporation	0.37	0.34

*Significant at 0.05 level
Source: Authors' Analysis

The work of Adedapo (2017) on the impacts of climate variability on vegetable crops in Ilorin, Nigeria using data on temperature, relative humidity, rainfall and sunshine hours collected for ten years analyzed with Multiple regression, trend analysis, correlation statistics and Standardized Anomaly Index (SAI) agrees with the findings of this work in regards to temperature and evaporation as the study revealed that the selected climatic elements have a weak impact on the yield of okra, sweet potato, pepper, and Amaranthus. However, on the contrary, all the selected climatic elements have a strong negative impact on the yield of tomatoes in that Adedapo (2017), hence a significant decrease in tomato production while in this study rainfall has a positive relationship with rice and tomato.

The works of Olubanjo and Alade (2018) on the effect of climate variability on the yield of crops in Ondo State, Nigeria contradicts the finding of this work. The study assessed the effect of observed climatic variables (rainfall, temperature and relative humidity) on the yield of some crops (cassava, yam, pepper and tomatoes) with nineteen years of data using SPSS 16.0 and Microsoft Excel in collaboration with Multiple regression, trend analysis, and ANOVA techniques and the study revealed that the rainfall range for the nineteen years which was 1013.08 mm; temperature 5.14°C and relative humidity 11.55% were found to have negative effects on cassava, yam, pepper and tomatoes yield by 20.7%, 18.6%, 26.8% and 15.5%, respectively unlike the findings of this study where none of the climatic variables harms the production of rice and tomato.

However, the study finding is also similar to the work of Olanrewaju, Tilakasiri, and Oso (2017) who worked on climate change and rice production in Ekiti State whose study revealed an upward trend pattern for rice production using climate data obtained from the archive of the Nigerian Meteorological Station, Oshodi, Nigeria and rice data from Ekiti State Agricultural Development Project (A.D.P). The data were summarized using a statistical tool of mean, Correlation and regression to find the strength of the relationship while the most critical climatic variable(s) for rice was identified using factor analysis. The result revealed that an increase in rainfall amount and frequency during the period shortly before planting and during planting seems to be very important for rice yield. Minimum temperature correlates highly with yield during the period of planting. A mild positive relationship exists between yield and temperatures (maximum and minimum). Temperature is most critical during harvest as both maximum and minimum temperature exhibited a high positive relationship of 0.82 and 0.66respectively.

Conclusion

The onset and cessation of rainfall for Tiga station downstream revealed the first decadal of May with cumulative percentage rainfall values of 7.94% for the onset and first decadal of October for a retreat with a cumulative percentage rainfall values of 92.56%. The Findings also revealed four months planting seasons for the station downstream while the relationship between climatic variable (rainfall, temperature and evaporation) and reservoir water level at 0.05 level of significance with the aid of SPSS version 20 software revealed a strong positive significant relationship for rainfall and reservoir water level with an R-value of 0.98. Hence, the null hypothesis was only rejected for rainfall and reservoir water level while accepted for temperature and evaporation on the reservoir water level.

Similarly, the relationship between climatic variables (rainfall temperature, evaporation) and crop yields tested at 0.05 level of significance with the aid of SPSS version 20 software, revealed a very strong positive significant relationship between rainfall, rice and tomato in the study area with an "r" value of 0.94 and 0.90 respectively. Temperature, evaporation on crops downstream was fairly positive but not strongly correlated hence; insignificant, so the null hypothesis was only rejected for rainfall on crops in the study, while challenges as reported from the Focus Group Discussion (FGD) also revealed that 80% of the farmers reported floods occurrences during the rainy season and deficit of water in the latter days of the dry period (mostly between January and March of each year). This might be a result of operational failures (poor storage facilities) in the reservoir station. The FGD further revealed that 83% of the farmers said they receive poor supports from the government. It was recommended that special projects and strategies should be adopted to address the issue of water deficit during the dry season and overflowing of the reservoir station during the rainy season as this will help to control surplus and deficit water inflow and outflow in all seasons as well as limits flooding, destruction of cultivated crops, arable lands and properties.

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