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ASSESSMENT OF CLIMATE SMART WATER MANAGEMENT FOR SUSTAINABLE IRRIGATION IN THE HADEJIA NGURU WETLAND, NORTHERN NIGERIA

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ABSTRACT

The study uses climate smart climate smart water management for sustainable irrigation in Hadejia Nguru wetland (HNW). The HNW has been identified with problem of irrigation water supply over the years due to climate change issues. Different researchers have investigated the reason why. The problem of irrigation in the area was anticipated with soil and water supply issue; the finding of the soil has indicated that the problem is not only in the soil but to climate related water. Because water is very important in irrigation. The study investigates into the climate smart water management practices. The study uses random sampling to select the seven villages' farms. The study shows that there is no problem with smart irrigation uses. But need improvement. Because the farmers are using old or local water management practices. The study uses descriptive statistics using table to explain the result obtained. It recommended that the government should provide formal irrigation sectors in the area and also provide new technology for sustainable irrigation.

Keywords*: Assessment, Climate, Smart, Water, Management, Irrigation.*

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INTRODUCTION

There is growing evidence of river basins vulnerability to climate change resulting in water stress problems including the use of water for sustainable irrigation in view of that the wetland, river basin and natural resources managers need adopting measures (climate smart) especially with regard to climate change that can be used to predict and therefore respond to change in the productive status of those resources especially water for sustainable irrigation in wetland areas. Climate smart water management include adaptation practice that reduced vulnerability and increase resilience to changing weather pattern such as drought and excess rainfall it also include mitigation practices that help sequester carbon through smart management . Water is a key to success in different aspects of life including agriculture. That is why its management is crucial particularly in areas with harsh climatic conditions associated with high temperature, law vegetation coupled with scanty or in adequate rainfall. Rilwanu, (2022). Climate smart agriculture is a pathway towards development and food security which is built on three pillars: increasing productivity and livelihood and ecosystem, reducing and removing greenhouse gas emission from the atmosphere. Agricultural sector is not only among the most vulnerable sectors to the impacts of climate change, it is also directly responsible for 14 percent global greenhouse gas emissions, in addition, the sector is a key driver of deforestation and land degradation, which account for an additional 17 percent of emissions. Barau, (2014).

Sustainable utilization of natural resources will require management and governance practices based on ecosystem approaches that involve multi-stakeholder and multi-sectoral coordination and cooperation. This is a crucial element for the transformation to climate-smart agriculture which is rooted in sustainable agriculture and rural development objectives which, if reached, would contribute to achieving the Millennium Development Goals (MDGs) by reducing hunger and improved environmental management. Barau, (2014).Agriculture is the most sensitive sector and greatly influenced by climate change and climate variability. The intergovernmental panel on climate change (IPCC 2014) in its fifth assessment report observes that climate change is already happening in South Asia and impacts are already being felt. With rising temperature and changes in precipitation pattern due to climate change it is likely to have serious implication on water resources availability and thereby affecting agriculture. In the 21st century climate change has emerged as significant challenge to agriculture, fresh water resources and the food security of billions of people. (Global and Rao 2018).

The effect of variation in rainfall pattern may affect the natural recharge process, and increased temperatures may enhance crop evapotranspiration and irrigation demand in a different parts of the world (Patle,2017) climate change is the usual weather found in a place this could be a change in how much rain a place usually gets in a year or it could be a change in place usual temperature for month or season climate change is also change in earth's Climate, this could be change in earth's usual temperature or it could be change in where rain and snow usually fall on earth Weather can change in just few hours. Climate takes hundred or even millions of years to change. Many thing cause climate to change all on its own on earth, distance from the sun can change. The sun can send out more or less energy. Ocean can change when volcano erupt it can change our climate (NASA 2015).

Most scientist say that human can change climate too people drive cars, people heat and cool rooms. People cook food. All this things take energy one way we get energy by burning cools oil and gas. Burning this thing put gases in to the air. The gases cause the air to heat up. This can change the climate of a place and also earth's climate (NASA, 2015). According to the last assessment report on impact, vulnerability and adaptation by the UN

intergovernmental panel on climate change in recent decades, change in climate have cause impacts on all continents and across the ocean (IPCC, 2014). Scientist says that ecosystem and much system are vulnerable and exposes to climate related extremes. In fact such climate related extremes includes alteration of ecosystem, disruption of food production and water supply, damages of infrastructure and settlement etc. (IPCC, WALL, 2014).

The effect of climate damage are unavailable for numerous generation to come but since they are somewhat predictable, there are some action human can now take to face it. The United Nation Framework Convention on climate change (UNFCCC) has identified mitigation and adaptation of the two most important reactions. Mitigation to climate change implies reducing greenhouse gas emissions and enhance sinks, which remove carbon dioxide (CO2) from the atmosphere sinks are either natural or artificial reservoirs that accommodate land store this polluting carbon chemical (IPCC, 2014). On the other hand adaptation means adjusting to the impact of climate change. Most of the industrialized countries have already signed treaties such as the Kyoto Protocol and the UNFCCC to reduce the overall greenhouse gas emissions, these efforts, have been over due and according to the IPCC, " no mitigation efforts, no matter how rigorous and relentless, will prevent climate change from happening in the next few decades" (IPCC 2007). Adaption is necessary measure, especially for developing countries which have means socio- economic and environmental vulnerability than the industrialization countries.

STATEMENT OF THE RESEARCH PROBLEMS

Wetlands all over the world have come under the negative impacts of climate change and this call for their restoration. Climate variability continues to be a matter of global concern due to the challenges it poses in all economic development sectors. While climate change is witnessed as a long-term alteration in climatic conditions, climate variability is the fluctuations experienced in weather patterns in a short period of time at a given location (Ringim, 2018).

The Hadejia-Nguru Wetlands represent one of the most important floodplain ecosystems in the Sudano-Sahelian region, supporting over one million people through irrigation agriculture, fishing, and livestock production. However, the sustainability of irrigation in this region is increasingly threatened by a combination of climate variability, hydrological alterations, and poor water management practices. Empirical evidence shows that the wetlands have experienced significant hydrological changes due to declining rainfall, prolonged droughts, and upstream river regulation caused by the construction of dams such as Tiga and Challawa Gorge. These interventions have altered natural flooding regimes, reduced downstream water availability, and contributed to the shrinking of the wetland area from about 2,350 km² in 1969 to less than 1,000 km² in the 1990s (DFID, 2004).

Going by a lot of problem in the study area affecting irrigation that are yet to be solved such as rail water reduction, reduction in the extent of flood and wetland which resulted in the drying of the pond of the wet land and reduction in the wetland value and crops yield. Also, most of the researchers in the area focuses on flood disaster and climate soil management among others, this research is intended to assesses how effective are the Climate Smart Water Management Practices in the study areas for effective irrigation.

AIM AND OBJECTIVES

The aim of this research is to assess Climate Smart Water Management Practices (CSWMP) for sustainable irrigation in the northern parts of Yobe State, Nigeria.

The aim is expected to be achieved through the following objectives to:

Objectives

i. Identify Climate-smart Water Management Practices for irrigation commonly practiced in the area.
ii. Examine how effective are the Climate-smart Water Management Practices for sustainable irrigation.
iii. Determine the extent to which adoption of CSWMP influences irrigation and food production in the area?

1.7.1 Location

Hadejia Nguru wetland, Nigeria is the study area for this study. It is situated between latitudes 12' 15'N'0' to 13'00N and longitudes 10'00'E to 11'00'E, bordered by Niger Republic to the North; Jigawa and Bauchi States to the West; Nagere, Fune and Tarmua LGAs in the south and Borno State to the East (Fig 1).

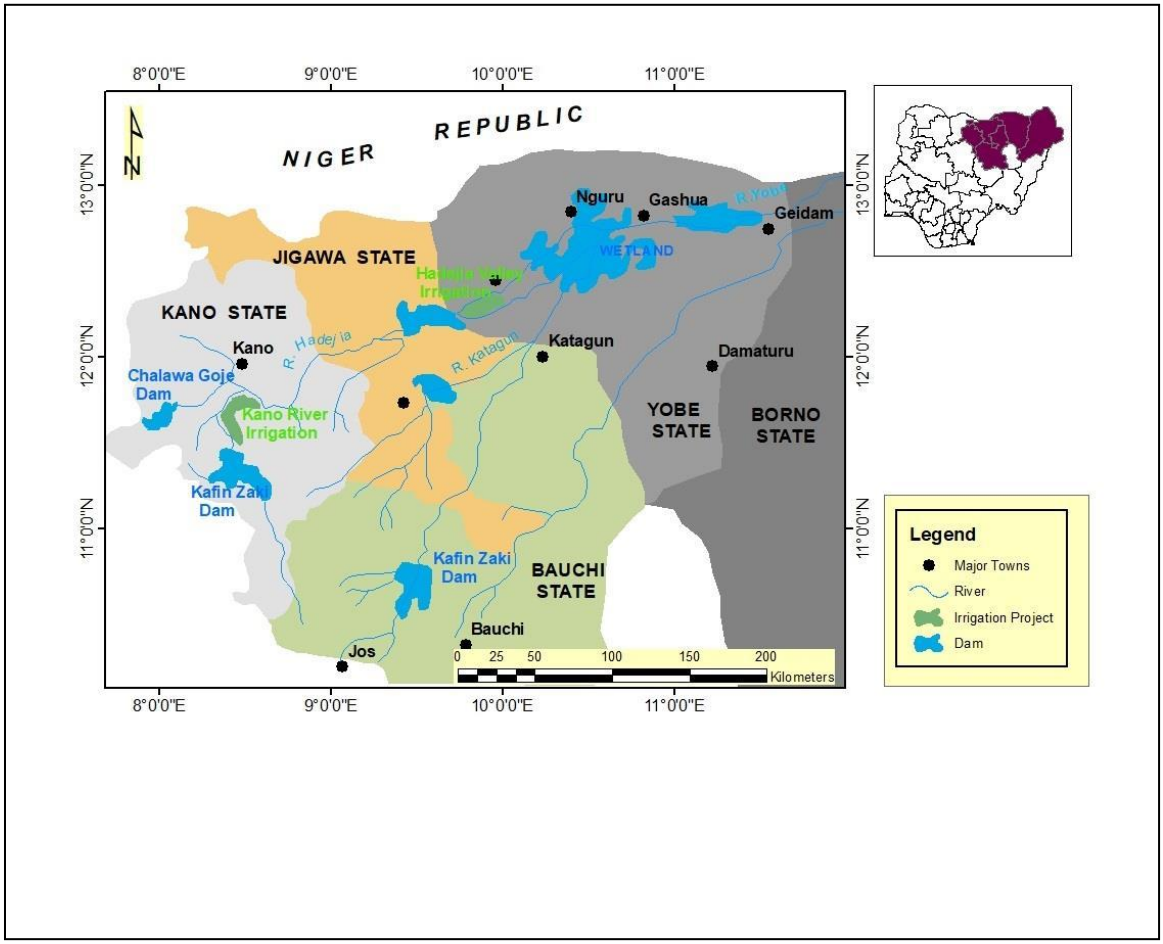

Fig. 1: Map of Hadejia Nguru wetland.
Source: Cartography Geography Department, BUK

3.0 MATERIALS AND METHOD

3.1 Research design

The research design of this study will involve reconnaissance survey, research design, types and source of data, population and sampling, data collection and data analysis to achieve all

the stages. A multiple research approach will be adopted for the data acquisition for a detailed irrigation water users in Hadejia Nguru Wetland Survey. For climate smart water management for sustainable irrigation. The research design will involve aspect of qualitative data like questionnaire administration to the farmers. This research approach is to contribute valuable insight for developing sustainable water resources management strategies for irrigation especially with regards to climate change challenges.

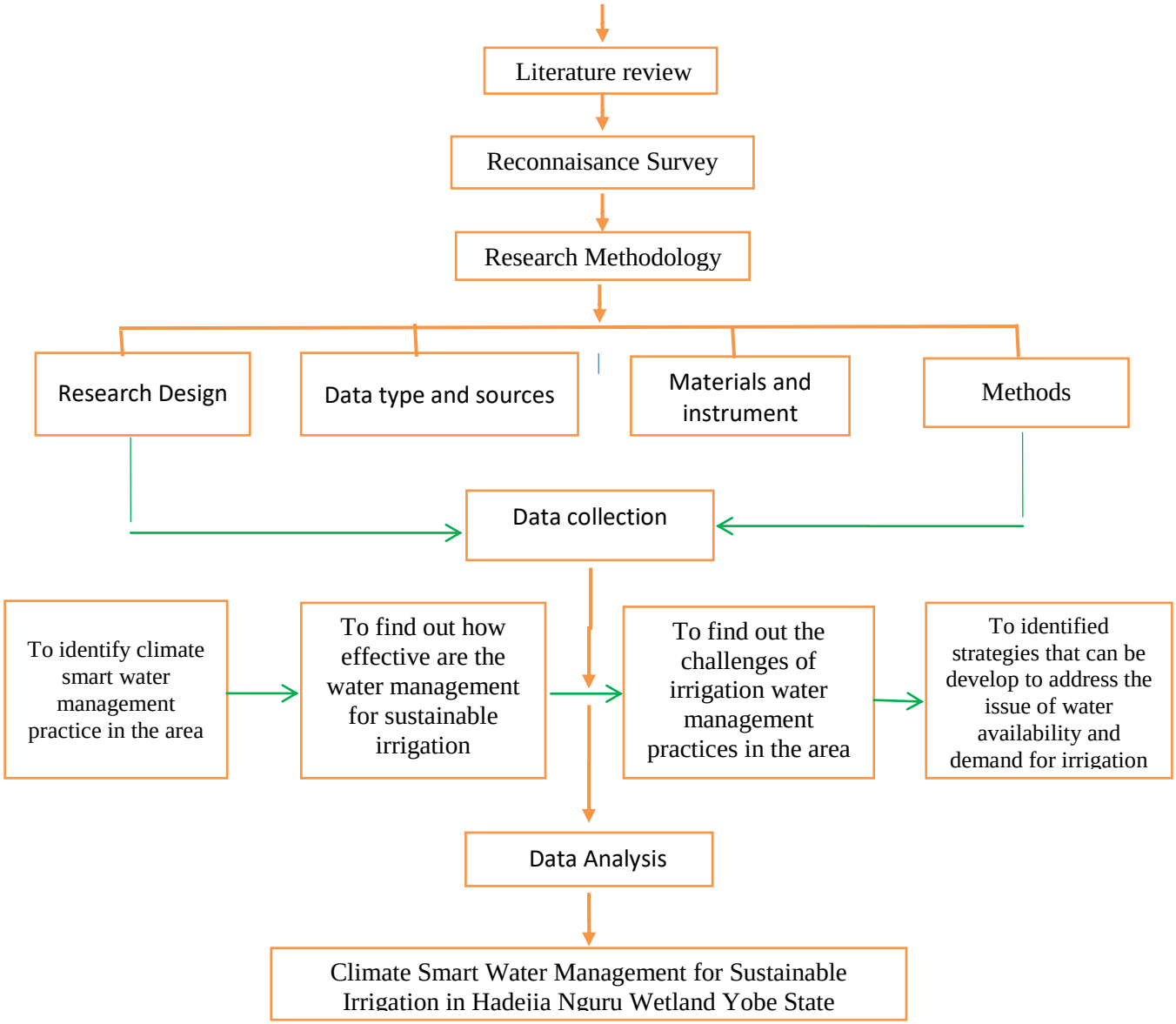

Figure 2: Flowchart of Research Design
Source: Researcher, 2025

3.5 POPULATION AND SAMPLING

The selected area for this study is Hadejia Nguru Wetland, the Hadejia Nguru Wetland are situated in north eastern Nigeria between the towns of Hadejia Nguru Gasua and Katagum. In the study area, all the irrigation sites are informal, therefore there are no sectors, in the absence of sections villages were the irrigation is practiced were selected, purposive sampling techniques were used in the selection of the villages. The study area in the villages are as

follows: Dabar Magini, Margadu, Tukwikwi, Mattara Uku, Dugil Fanni, Mattafari, Adiani, Dogona, Dalla, Gabarwa, Tagali and Sugum making thirteen (13) in number and the justification for selecting these (13) village is base on the fact that they are the ones that have organized functional farmers association and are all registered. The total number of registered farmers in villagers stand at seven hundred farmers (700) this was found during the reconnaisance survey and the numbers were as follows: Garbi (60) farmers Dabar Magini (60) Margadu (50) Tukwikwi (39) Matara Uku (74) Dagil Fanni (38) Muttafari (55) Adiani (79) Dagona (54) Dalla (59) Gabarwa (24) and Tagali (64) and Sugum (44) making a total of 700 farmers which form the population size of the sample that is 700 the number was compared in the table for determining sample size from given population (Krejcie and Morgan, 1970) according to the table two hundred and forty eight should be the sample size and can be used to calculated the required sample for each village as indicated in the table (1 and 2) below.

Because of time constraint and for the purposes of this paper seven village where selected using random sampling. All the names of the villagers where written and put in a container, where selected randomly for this work. The seven selected where as follows, Garki, Dabar Magini, Margadu, Tukwikwi, Dagana, Dalla and Gabarwa.

For Garki = 60700 x 248 = 21.25 ⊐ 21
For Dabar Magini = 60700 x 248 = 21.25 ⊐ 21
For Margadu = 50700 x 248 = 17.71 ⊐18
For Tukwikwi = 39700 x 248 = 13.81⊐ 14
For Matara Uku = 74700 x 248 = 26.21 ⊐ 26
For Dagil Fanni = 38700 x 248 = 13.46 ⊐ 13
For Muttafari = 55700 x 248 = 19.48 ⊐ 19
For Adiani = 79700 x 248 = 27.98 ⊐ 28
For Dogana = 54700 x 248 = 19.31 ⊐ 19
For Dalla = 59700 x 248 = 20.90 ⊐ 21
For Gabarwa = 24700 x 248 = 8.50 ⊐ 9
For Tangali = 64700 x 248 = 22.67 ⊐ 23
For Sugum = 44700 x 248 = 15.58 ⊐ 16

Table 1: Showing the selected villages from the Local Government under Hadejia Nguru Wetland

S/N	Sample Local Govenrments Under Hadejia Nguru Wetland	Sample Villages
1.	Nguru Local Government	Garbi
2.	Guri Local Government	Dabar Magini Margadu Tukwikwi
3.	Bade Local Government	Dogana Dalla Gabarwa

Sources: Field Survey, 2026

Table 2: Showing sampling number of farmers using Krejcies and Morgan formula

S/N	Sampling point (Area of high Irrigation Activities)	Population of Registered Farmers	Number of Farmers to be Sample
1.	Garbi	60 farmers	21
2.	Dabar Magini	60 farmers	21
3.	Margadu	50 farmers	18
4.	Tukwikwi	39 farmers	14
5.	Dagana	54 farmers	19
6.	Dalla	59 farmers	21
7.	Gabarwa	24 farmers	9

Source: Field Survey, 2026

RESULT

Table 3: Demographic Characteristics of Farmers and Farm Profile in the Study Area

VILLAGES AND NUMBER OF QUESTION NEAR DISTRIBUTED	SEX		AGE RANGE						DISTANCE FROM RIVER /CANAL			FARM SIZE UNDER IRRIGATION			MAIN CROP GROWN				WATER SOURSE				YEARS OF FARMING			
	M	F	01-20	21-30	31-40	41-50	51-60	60-ABOV	< 1KM	1-3 KM	>3KM	<1 HA	1-3 HA	>3 HA	RICE	WHEAT	VAGETABLE	OTHERS	DAMN/RIVER	SHALLOWWELL/ TUBE WELL	WET LAND/MIXED	OTHERS	1-20	21-30	31-40	41-ABOVE
GARBI (21)	21	-	-	06	05	04	02	03	11	03	07	06	15	-	09	04	04	04	12	03	06	-	11	04	04	02
TUKWIKWI (14)	14	-	-	02	04	05	03	-	05	03	06	04	08	02	07	01	06	-	03	10	01	-	12	02	-	-
MARGADO (18)	18	-	01	03	-	02	11	01	02	08	08	-	06	12	10	08	-	-	06	04	08	-	12	06	-	-
DABAR MAGINI (21)	21	-	-	06	06	06	-	03	07	09	05	-	13	08	13	02	04	02	13	06	02	-	18	01	02	-
DAGANA (19)	19	-	-	02	07	03	05	02	-	10	09	01	08	10	14	-	05	-	10	04	05	-	15	04	-	-
GABARWA (09)	09	-	-	01	02	03	02	01	-	06	03	02	03	04	05	02	02	-	05	02	02	-	09	-	-	-
DALLA (21)	21	-	-	02	03	08	06	02	-	07	14	04	13	04	10	07	04	-	06	10	05	-	10	10	01	-

Source: Field Work, 2026.

From the above table, it shows the demographic and farm profiles of the farmers it indicate that, All of the farmers in the study area were male and majority of the respondents fall within the age category of 21 – 30 and 31 – 40 years less in the category of the above 60 year and below 20 years which indicate that most of the irrigation is being undertaken by the youth.

Table 4: Smart Water Practices in the Farm Villages

SMART IRRIGATION PRCTICE									
VILLAGE AND NUMBER OF QUESTIONIER	DRIP IRRIGATION	AWD	LINEED CANAL	MOISTURE CENCUS	NIGHT IRRIGATION	MULCHING	FLOODING	SPRINCLER	OTHERS
GARBI (21)	01	11	03	-	01	06	12	-	-
TUKWIKWI (14)	03	06	-	-	05	02	03	04	-
MARGADO(180	03	11	04	-	-	-	19	02	-
DABAR MAGINI (21)	01	15	01	-	03	03	12	06	-
DAGANA (19)	01	14	01	-	02	-	16	03	-
GABARWA (9)	01	06	01	-	-	-	07	02	-
DALLA (21)	04	15	04	-	-	-	21	01	-

Source: Field Work, 2026

The table indicate the various smart irrigation practice in the study area which include Drip irrigation alternate wetting and drying, lined canal, moisture sensor, night irrigation, making, flooding, sprinkle and any other one that is not outline, the result shows that most of the farmers in almost All the seven (7) villages practice their irrigation through flooding that is when water over flow they use it to irrigate their crops, flow by the AWD and drip irrigation which some uses night irrigation and non are using modern system line moisture sensor and few used sprinkler .

Table 5: Effectiveness of smart water practice base on the following variables and rate from
1 - 5 (1 = very poor, 3 = good, 4 = very good, 5 = excellent)

Villages and number of Questionnaire.	**Save Water**	**Increate Crop yield**	**Reduce labor and time**	**Low cost**
Garbi (21)	Very good and excellent	Very good and excellent	Good	Good
Tukwikwi (14)	Good	Very good	Good	Good
Margadu (18)	Excellent	Very Good	Good	Good
Dabar magiini (21)	Very Good	Good	Good	Good
Dagana (19)	Good	Good	Very Good	Good
Gabarwa (9)	Very Good	Good and Very Good	Very Good	Very Good
Dalla (21)	Good and Excellent	Very Good	Good	Excellent

Source: Field Work 2026

The table shows the effectiveness of the practice chosen based on scale from one to five.

Where 1 = Very Poor, 2 = Poor, 3 = Good, 4 = Very Good, and 5 = Excellent.

It shows that, based on the following variables, that is save water, increase crop yield, reduce labor and time and low cost, the farmers' selected practices show that it ranges from good to excellent, which also indicate increase in their yield.

Table 6: Extent of influence on irrigation and food production based on average yield, before smart practice and after smart practice bags/hectares.

Village and no. of Questionnaire	Yield before Smart Practice bag/ha	Yield after smart Practice bags/ha
Garbi (21)	20 Bags/ha – 32 Bags/ha	57 Bags/ha – 65 Bags/ha
Tukwikwi (14)	26 Bags/ha – 45 Bags/ha	60 Bags/ha – 70 Bags/ha
Margadu (18)	30 Bags/ha – 45 Bags/ha	65 Bags/ha – 70 Bags/ha
Dabar magiini (21)	25 Bags/ha – 50 Bags/ha	65 Bags/ha – 72 Bags/ha
Dagana (19)	35 Bags/ha – 60 Bags/ha	60 Bags/ha – 80 Bags/ha
Gabarwa (9)	40 Bags/ha – 55 Bags/ha	65 Bags/ha – 75 Bags/ha
Dalla (21)	45 Bags/ha – 65 Bags/ha	65 Bags/ha – 80 Bags/ha

Source: Field Work 2026

The table shows that the choice of climate smart water management practice is in the right direction by the farmer because in each village there's an increase in yield after adopting climate smart practice, example in Garki before smart practice the obtained 20 Bags/ha - 32 Bags/ha but after smart practice the yield increase to 57 Bags/ha – 65 Bags/ha.

In all the villages, the result shows that there is an increase in the yield.

Conclusion

The study assessed climate smart water management practice for sustainable irrigation in Hadejia Nguru wetland. It was found that most of the practices are the traditional irrigation practice or old practice like flooding and alternate wetland and drying. The study was carried out in seven selected villages based on that there's problem of adopting new method of climate smart water management for sustainable irrigation and recommend the implementation of such technologies by the government.

To enhance food production in the area, it was recommended that all stakeholders should work together; example NGO, Government and the farmers.

Recommendation

The study recommends that:

1. More technological equipment for the irrigation water should be provided in the area.
2. Provision and maintenances of infrastructure such as feeder roads construction of bridge in the area.
3. Construction of formal irrigation area like that Hadejia Jama'are river basin development authority with dam, channel, Distribution channel, reservoirs and field channel.
4. Public enlighten to the farmers, on new irrigation systems, using technology and even solar energy.
5. Others new climate smart water management like rain water harvest should be adopted by the farmers

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