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INDIGENOUS WATER MANAGEMENT PRACTICES IN DRY LAND ENVIRONMENT: A SITUATION ANALYSIS IN JAMA'ARE L.G.A OF BAUCHI STATE

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ABSTRACT

The study aimed at analysing the Indigenous Water Management Practices in Jama'are LGA of Bauchi State. A total of 400 questionnaires were administered in Ten (10) wards of the study area using Cluster sampling, technique and interviews. The data generated was analyzed using both descriptive and inferential statistics (Dependent sample t-test. The Weighted Criteria Matrix (WCM) was also used as qualitative tool in the study. The study identified five (5) types of indigenous water management practices which are Groundwater harvesting (*Lalalo*), Runoff harvesting (*Tafki and Bingi*), Rooftop harvesting (*Indororo*) and Shadoof (*Jigo*). The result of the t-test indicates that *lalalo*, *Bingi* and *Indororo* have significant differences in water availability between dry and wet season while for *Tafki* there is no significant differences in water availability between dry and wet season. For the ANOVA test the result indicated that there is no significant difference in water level between the five studied districts. From the analysis of the WCM which revealed that runoff harvesting practices are more productive and sustainable practices. The study recommends buffering of water sources, formulation of policies and regulations toward the use of indigenous water management practices, advocacy, and improvement of rooftop harvesting, enhancement of community participation in water development programmes.

Keywords: Indigenous, Water Management Practices, Dry land, Environment

INTRODUCTION

Water is the most fundamental and indispensable natural resource (Olokesusi, 2006). It is an essential element of qualitative life and among the world most variable gift of nature. Every living thing require water to sustain life, therefore, man's effort to improve his quality of life is incomplete without sound water management. Water as a natural resource is not evenly distributed, in some locations it is in abundance while in others it is scarce, especially in dry lands which have an unpredictable source of supply characterized by erratic rainfall and high inter-annual climate variability. Water is undoubtedly a major environmental constraint in dry lands where traditional underground water supply systems and surface-water harvesting methods were used in such environmental settings (Arzani, 2010). These uncertainties of erratic rainfall, frequent drought, high inter-annual climate variability and low level of biological productivity have consistently affected water sources and their supplies which in combination with social, economic, and political factors have adversely led to water insecurity, conflict in utilization of the water resources, persistent water scarcity and marginalization, among others.

Man's aspiration to continuously improve the quality of his life compel him to device several strategies either individually, collectively or institutionally to build up knowledge on managing their water resources which is passed from one generation to another, which is referred to as Indigenous Knowledge (IK). Indigenous Knowledge is a mixture of knowledge created endogenously within the society and knowledge acquired from outside but then absorbed and integrated within the society (Ahmed, 1994). In another term it is a systematic body of knowledge acquired by local people through the accumulation of experiences, informal experiments and intimate understanding of the environment in a given culture (Warren, 1993).

Through gathering Indigenous knowledge and transfer from generation to generation had led to establishment of traditional Institutions by indigenous people who include norms and procedures that shape people's actions. These procedures define practices, assign roles and guide interactions. These institutions play key role in the management of natural resources through different form of indigenous technical knowledge, among which water is one (Richard et al., 2014).

Traditionally, water is perceived by the indigenous people to be managed for two major purposes, namely agriculture and domestic consumption. Indigenous water management techniques have been developed over the past, especially in dry and mountainous areas. The two major techniques of water harvesting are micro-catchments which involve trapping of runoffs using embankments, pits and roof collection. In most African countries, surface water bodies are regarded as common property resources. All community members are entitled to equal rights of access and use of the water (Olokesusi, 2006).

Indigenous water management practices have been in existence apparently in Jama'are Local Government Area, long before the introduction of concrete wells and boreholes. An area of predominantly flat plain, characterized with two (2) geological formations which are Basement complex and

Chad formation. The areas mostly underlain with basement rock are mostly associated with in ability of accessing water (KomaduguYobe Basin Project (KYBP), 2006). While areas on Chad formation have more are more accessible to better potential for water supply with Jama'are River serving as enabling factor which cut across the Chad formation. During the wet season, the people enjoy the privilege of rainfall to increase their water supplies for their domestic and agricultural consumption alongside waters from wash bore, boreholes and trapping of runoffs. Rooftop harvesting is obviously common during raining season but limited to house owners with corrugated metal roofs. In the dry period most of the available sources of water supply dries off, including some of the modern water supply sources which consequently enforce communities to invest substantial effort in search of water (Sule 2017).

RESEARCH METHOD

Description of the Study Area

Jama'are Local Government Area is located in the Sudano-Sahelian region of Nigeria, north of Bauchi State on latitude 11˚35ˈ and 11º 50ˈNorth and longitude 9˚45ˈand 10º 50ˈ East. It shares boundaries with other local governments situated in Bauchi State like: Itas-Gadau Local Government to the North, Katagum to the East, Shira to the South and Kiyawa Local Government of Jigawa State to the West as shown in Figure 1. It was administratively created as local authority in 1976. It has a surface area of 493 square kilometres with its population at 117,883, according to 2006 Census report (Thomas, 2011).

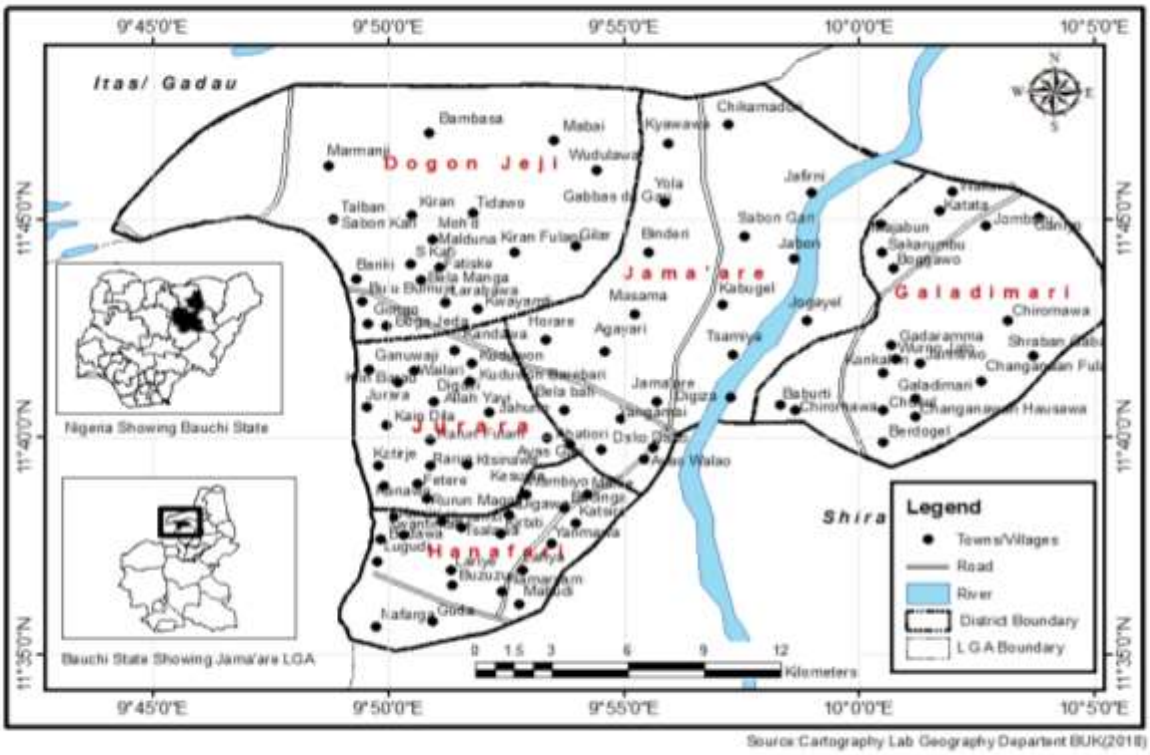

Fig. 1: Map of the Study Area

Sampling

Based on 2006 Census report, the study area had 10 wards with a total of 5 Districts head office with population of 117,883 which was projected to year 2016 to obtain a population of 166,465 using exponential method with growth rate of 3.5% for a period of 10 years (Table 1).

Table 1: Ten Years Projected Population of Study Area

SN	Location	Population (2006)	Projected Population
1	Jama'are	51,869	73,245
2	Dogon-Jeji	24,755	34,958
3	Hanafari	17,682	24,970
4	Galdimari	14,146	19,975
5	Jurara	9,431	13,317
	TOTAL117,883		166,465

Source: National Population Commission (2006)

Based on the projected population of the study area, the sample size was determined using Krejicie and Morgan (1970) table to determine the sample size of 383 for a population of 166,465. However, considering the needs to have equal representation and precision a total of 400 respondents were sampled which was divided against the number of wards (10) to determine the sample size of 40 respondents in each of the ward within the study area.
Cluster sampling method was employed due to the dispersed nature of the settlements within the wards, with the total of ten (10) wards existing in the study area determined as the clusters. In each of the cluster, a total of 40 indigenous respondents (persons) were purposely and randomly targeted, giving an aggregate of 400 respondents sampled in the study area. For the purpose of collection of hydrological data, the responses obtained during from the questionnaire administration were used to identify and mark locations using various indigenous water management practices. Out of 36 locations using *Tafki* (Runoff water harvesting), 20 settlements were randomly selected and in each a site is purposely selected for the on-site study which are located in Jurara, Galdimari, Hanafari, Dogonjeji (B and C) and Jama'are (A and C) wards. The *Bingi*(Runoff water harvesting) which was identified with 9 users location, the whole nine locations were selected for the on-site study which are in Jurara, Galdimari, Hanafari and Dogonjeji (C) wards. From 20 user locations of *lalalo (Groundwater harvesting)*, 20 sites were also selected which are in Jurara, Hanafari, Dogonjeji (A and B) wards. Out of the 20 identified users location of *Indororo*(Rainwater harvesting), 19 sites were purposely selected due to accessibility for the on-site study which are located in Galdimari, Hanafari, Dogonjeji (B) and Jama'are (A, B, C and D) wards.

Data Collection and Analysis

Both Qualitative and Quantitative methods were employed for the analysis which involves use of descriptive statistical tools such as tables, percentages, bar charts, means which were all used for the purpose of having clearer presentation of data, easier comparison and computations; inferential statistics such as Two-sample t-test were used for statistical hypothesis testing. Interpretation, image display and quotations were also used to report data acquired through interview and physical observation. All presented in Results and Discussion.

The Weight criteria method was used to identify the indigenous water management practices that are more productive and sustainable which for the study. The WCM is a qualitative tool use in evaluating set alternatives. In other words, is a simple tool that can be used in taking decision. It requires setting out well defined individual criteria, determining weights based on importance of criteria, providing reference against which comparisons will be made and lastly, having alternatives that will be ranked. The rationale behind using this tool is its ability in decision making processes.
In reference, ten (10) criteria were established (Table 2) which was weighted in percentage based on the level of importance and a rating scale ranging from 1-5 was also determined and used in the study. For the purpose of clarification water requirement standards were also adopted from Falkenmark indicators (1989), Gleick (1996), FMWR&RD (2004) which were used as benchmarks. Computation tools utilized for the study is the Microsoft Excel 2010 package and online calculator accessed from California Aquaculture (http//:aqua.ucdavis.edu/calculations) which was used to determine the water availability in litres for the groundwater source (*lalalo*) based on:

Water availability/storage $=\pi r^2 . \mathrm{h}$ .... (1)

While for the runoff sources the volume was determined using surface area and average depth, measurements were taken in litres.

Table 2: Weighted Criteria Matrix

S/N	Criteria	Justification for the Choice
1	Quantity of water available from source	Water availability attracts patronage, the much available the more the uses.
2	Distance of water source to host community(s)	The more the distance the more the stress and difficulty of accessibility which affects livelihood.
3	No. Of persons per water source(s)	The more persons/livestock per source the more pressure and eventual shortage of water supply.
4	Collection time per user	This criterion is also affected by quantity and distance and have tendency of affecting livelihood.
5	Number of activities subjected to water use by host community(s)	The higher the level of water availability the more uses the water source is subjected.
6	Impact of practices on agricultural productivity	Possible impact of water quantity in increasing agricultural productivity.
7	Impact of practices on livestock water requirement	Possible impact of water quantity in increasing livestock water requirement.
8	Community participation in indigenous water development and management practices	With community participation, maintenance and sustainability is mere possible.
9	Impact of indigenous water management practices on the physical environment	Possible negative practices can cause degradation on the physical environment.
10	Community skills capacity to sustain indigenous water management practices	The Higher the level of indigenous skilled manpower the more possibility of sustaining the practices

Source: Field survey, 2016

RESULTS AND DISCUSSION

Indigenous Water Management Practices in Jama'are Local Government

The study revealed that four (4) major indigenous water management practices exist in Jama'are Local Government which is identified based on the information obtained from the questionnaires administered to the respondents and interviews conducted. The *Taki*, *Bingi*, *Lalalo* and *Indororo* practices are the major indigenous water management practices that are in use in Jama'are Local Government which are also utilized in harmony to modern water management practices. Based on respondents identification of types of indigenous water management practices used in their various communities, the users of *Tafki* accounts for 26.5%, the *Bingi* 4%, *Lalalo* 14.25%, Rooftop harvesting 9.25% while those respondents who uses none of these practices(modern technology) accounts for 46.25% as presented in table 5. This is contrary to the study in Khambashe that most of the practices or tools of indigenous water management are not common in present day Khambashe except the practice of digging well (Mahlangu and Garutsa, 2014).

Table 3: Types of Indigenous Water Management Practices

Practices	Number of Respondents(users)	Percentage
Lalalo (Groundwater harvesting)	57	14.25
Bingi(Runoff harvesting)	16	4.00
Tafki (Runoff harvesting)	105	26.25
Indororo(Rooftop harvesting)	37	9.25
Non-Indigenous (Introduced Technology)	185	46.25
Total	400	100.00

Source: Field survey, 2016

***Lalalo* (Ground Water Harvesting)Practices**

Description of Lalalo (Groundwater Harvesting) Indigenous Practice

This involves digging of pits which are usually shallow in nature and cylindrical in form (plate 1). It is usually developed in areas where water settles due to existence of gentle slope which serves as a micro-catchment for runoffs during the raining season. The captured water gradually infiltrates to the ground beneath the soil in form of recharge serving as a water bank. The infiltrated water is concealed by deposition of washed away soils into the pits and consequently causing reduction of the pits depths in the raining season. To enable users to make use of the pits adequately, they have to dredge the pits whenever required.

The practice commences usually in October of every year when the raining season seized completely to supplement for water provision in the dry season for the various users (Plate 1). The depth and diameter of the water source varies. The diameter is determined by discretion of the diggers while the depth is determined when the level of discharge of water from the ground is reached with certainty. The lalalo method accounts for 14.25% of the indigenous water management practice used by the respondents in Table 4 in the study area.

Plate 1: *Lalalo* water pit structure and shallow depth in Fetere Village
Source: Field survey, 2016

Characteristics of the Lalalo (Groundwater harvesting) Water Source

Further observation and measurement of the water source structure was taken during the course of the field work to determine the depth, width and quantity of water yielded in litres of the sampled pits during the period of study as shown in Table 4.

The depth of the pits varies with season as determined from the findings on sampled pits, with the dry season having a recorded depth range between 2.60m to 6.00m and in the wet season with a recorded depth of between 1.40m to 4.30m, both having a mean depth of 3.64m and 2.4m, indicating a shallow nature of the pits. Average water availability measured from the sampled pits during the study period in the dry season is 5,521.43litres and a mean value of 18,526.66litres in the wet season (Table 5). These implies a variation in depth and water availability from the source, with dry season having a deeper depth than in the wet season due to further dredging to search for available water from the ground. Water availability in the wet season is much more available due to recharge from rainfall during the season.

Development and Maintenance

The development and maintenance of this source is carried out by mainly the communities using simple tools like hoes, diggers, spade, local ladders (made from plants) and containers as observed during the study. An average of three (3) pits are dug and used by a community in a year for duration of an average of three (3) months.

Table 4: Characteristics of *Lalalo* (Groundwater harvesting) Water Pits

Location		Dry Season Month of November				Wet Season Month of July				
	Width(m)	Depth(m)	Storage Capacity(ltr)	Water Level(m)	Available Quantity(ltr)	Depth(m)	Water Level (m)	Available Quantity(ltr)	**No. of Spots**	**Duration of Use (Months)**
Jurara Geo-Political District										
Ganuwaji	3.1	3.50	26,447.05	0.60	4533.78	1.70	1.90	14356.97	3	3
Fetere	3.5	3.00	24,768.31	1.00	9632.12	2.00	1.78	17145.18	3	6
Katirje	3.1	4.00	30,225.20	0.40	3022.52	3.00	3.10	23424.53	4	6
KafinDila	3.3	3.20	27,400.83	0.30	2568.83	2.00	1.40	11987.86	5	3
Kuduwon Barebari	3.0	3.00	21,229.98	0.81	5732.09	1.40	1.60	11322.66	3	3
Rarum J. Magaji	3.5	2.60	25,043.51	0.44	4238.13	0.50	1.00	9632.12	3	2
Dagelji	2.7	3.10	17,769.49	0.62	3553.9	3.00	2.60	14903.45	5	3
Allah Yayi	3.4	3.50	31,813.52	0.90	8180.62	3.20	2.90	26359.77	4	3
Wailare	3.3	5.00	42,813.80	0.54	4623.89	3.78	3.00	25688.28	4	6
KafinBarau	2.9	3.20	21,160.79	0.73	4827.3	2.81	2.30	15209.32	3	3
Kanawa	3.0	3.40	24,060.65	0.77	5449.03	2.54	2.00	14153.32	3	3
Total	34.8	37.5	292733.1	7.1	56362.2	25.9	23.6	184183.5	40	41
Mean	3.2	3.4	26612.1	0.6	5123.8	2.4	2.1	16744	4	4
Hanafari Geo-Political district										
Kuyamti	2.8	3.00	18,493.67	0.75	4623.42	1.83	1.10	6781.01	3	2
Total	2.8	3.0	18493.7	0.8	4623.4	1.8	1.1	6781	3	2
Mean	2.8	3.0	18493.7	0.8	4623.4	1.8	1.1	6781	3	2
DogonJeji Geo-Political District										
Gabas da Gari	3.4	5.00	45,447.89	0.55	4999.27	3.00	3.30	29995.6	5	7
BuluBumuji	4.0	5.00	62,903.65	0.42	5283.91	3.51	3.00	37742.19	3	5
Kira	3.5	3.10	29,859.58	0.98	9439.48	1.20	0.90	8668.91	5	3
Kwayamti	3.0	4.20	29,721.97	0.78	5519.8	3.00	3.20	22645.31	5	3
Talban sabonkafi	3.6	3.00	30,571.17	1.00	10190.39	2.60	2.90	29552.13	3	3
Eldawo	2.6	3.00	15,946.07	0.80	4252.29	0.45	0.60	3189.21	5	4
Mohd Malduna	3.2	6.00	48,310.00	0.50	4025.83	4.30	4.00	32206.67	4	6
Bela-manga	3.0	3.00	21,229.98	0.81	5732.09	2.00	2.20	15568.65	3	3
Total	26.3	32.3	283990.3	5.8	49443.1	20.1	20.1	179568.7	33	34
Mean	3.3	4.0	35498.8	0.7	6180.4	2.5	2.5	22446.1	4	4

Source: Field survey, 2016

Dependent sample t-test was employed for testing the hypotheses on the significant differences in water availability in *Lalalo* between dry and wet season and result presented in Table 9 shows that there is significant differences at significant level of 0.05 in water availability between the two seasons with the t-value given at -6.03 at 19 degree of freedom and a p-value of <0.001. This commensurate with physical measurements of means of the two seasons with the wet season having a higher value, indicating more water availability in wet season than dry season.

Bingi Practices (Runoff Harvesting)

Description of Bingi (Runoff Harvesting) Indigenous practice
This type of practice involved excavation of the ground to a determined depth and width, use as catchments to trap runoff waters from rainfall or flood from the rivers for those developed close to the rivers. The "*Bingi*" is what is referred as Pond in literal terminology. It is used in the farms for storing water for irrigation farming while others develop it along gentle slopes in their communities as water catchments for their domestic and livestock consumption.

This practice has been in existence for over fifty (50) years as ascertained from the in-depth interview conducted with the various village heads/*sarkinruwa*. In the past it was usually use in conjunction with Shadouf system which is locally referred as *Jigo* to draw water out from the storage which also served as catchment to water the crops in irrigation fields. This is used by 4.00% of the respondents who sourced their water for various uses (Table 6).

Plate 2: Active *Bingi*water source expanded by erosion in Gongo Area of Dogon-Jeji
Source: Field survey, 2016

Characteristics of the Bingi (Runoff Harvesting) Water Source
Details of the width, length, size and average depth of the water source was measured during the field measurement and summarized as follows.

The study revealed that the average depth of the water source is approximately 3m with average width of 19.04m and average length of approximately 35m. Sizes ranges from 59.25m² to 1,710m². Average water available from the sampled source in dry season is 157,851.11litres and 2,313,978litres in the wet season (Table 6). This indicates that water is more available to users in the wet season than in the dry season. Duration of use of the source is averagely 3 months after the months of raining season. Out of the nine (9) sampled sources, only three (3) of the sources are active throughout the year (Plate 2). These sources are located in Gongo, Ganuwaje and Chirornawa while others are characterized by frequent dryness (Plate 3)

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Plate 3: Drying *Bingi*water source with a user in Ganuwaji Area of Jurara

Development and Maintenance

Development and maintenance of this source is carried out mainly by the communities which involves excavation to a certain depth, averagely 3 metres. Maintenance is only carried out on frequently dried sources by expanding their size and in some occasions refilling of eroded parts. The t-test carried out to test the hypotheses that there is no significant differences in water availability between dry and wet season in *Bingi* determined a t-value of -3.55 at 8 degree of freedom and a p-value of 0.007 which is less than 0.05, indicating a significant differences in water availability in litres between dry and wet season in *Bingi*. Thiscommensurate with the data obtained from the field measurement.

***Tafki* Practice (Runoff Harvesting)**

Description of the Tafki Indigenous practice

This is another practice discovered during this study that involved use of runoff water from the rainfall. It is usually developed in gentle slope areas, usually not too deep, rectangular in size, with varying sizes depending on the capability of its developers and provided space (Plate 3).It involves forming of catchments which is surrounded by earthen bunds to prevent loss of the trapped water obtained from the runoffs. The practice has been in existence for the past fifty (50) years as ascertained from the in-depth interview conducted.

In literal terminology, it is referred as earthen dam, usually use in domestic water supply and livestock watering. The user of such practice accounts for 26.5% based on the respondents' information gathered (Table 8). The water source is similar to the characteristic of the *Hafir*, which is typically located on land with gentle slopes which is created by excavation with spoils used to construct bund around its perimeter (Olokesusi, 2006)

Plate 3: *Tafki* water source catchment in Jurara Village
Source: Field survey, 2016

Characteristics of the Water Source

Details of the width, length, size and average depth of the water source was measured during the field measurement (Table 8).

The study revealed that the mean average depth of the water source is 0.61m, width 5.96m, length 29.50m and mean average size of the water source is 943.4m. The mean water available measured from the source during the dry season and wet season is 92,171.50litres and 1,900,026.50litres respectively, which indicates that the source have more water available during the wet season (table 8).

Table 8: Dimension and Capacity of *Tafki* Water Source

Location	Width (m)	Length (m)	Size (m^2)	Average Depth (m)	November Available capacity (ltrs)	July Available capacity (ltrs)	Durationof Use (Months)
Jurara Geo-Political District							
Jurara Town	80	100	8000	4.00	600,000	32,000,000	12
Ganuwaji	12	21	274	0.45	18,000	123,470	5
Total	92	121	8274	4.45	618000	32123470	17
Mean	46	60.50	4137	2.23	309,000	16061735	9
Galdimari Geo-Political District							
Changanawo Fulani	10	25	250	0.51	25,500	127,500	7
SharabanGabas	3	8	24	0.40	0	9,600	7
Chukkol	6	11	66	0.37	0	24,420	7
Baburti	13	22	286	0.43	0	122,980	7
WuroJalo	7	16	112	0.52	0	58,240	7
Total	39	82	738	2.23	25500	342740	35
Mean	7.8	16.4	147.6	0.45	5100	68548	7
Hanafari Geo-Political District							
Nafarga	5	14	68	0.42	0	28,350	5
Lugudi	10	22	220	0.38	7,980	83,600	5
Lariye	15	32	480	0.50	20,000	240,000	5
Kwantimari	35	80	2800	0.74	444,000	2,072,000	5
Buzuzu	5	11	55	0.38	0	20,900	6
Namaryam	7.3	10	73	0.33	0	24,090	5
Mahudi	3.5	7.9	28	0.30	0	8,300	5
Total	80.80	176.40	3723.15	3.05	471980	2477240	36
Mean	11.54	25.20	531.88	0.44	67425.71	353891.43	5
DogonJeji Geo-Political District							
Bambasa	4	6.2	25	0.35	0	8,680	6
Bariki	7	13	91	0.39	5,850	35,490	6
Bela-manga	50	80	4013	0.56	470,400	2,247,000	9
kiranFulani	10	21.2	212	0.40	18,000	84,800	7
Total	71	120.65	4340.3	1.7	494250	2375970	28
Mean	17.75	30.16	1085.08	0.43	123562.5	593992.50	7
Jama'are Geo-Political District							
Jafurni	24	61	1436	0.37	166,500	531,300	5
Ayasjaurogari	12.3	29	357	0.42	67,200	149,810	5
Total	36.30	90	1792.70	0.79	233700	681110	10
Mean	18.15	45	896.35	0.40	116850	340555	5

Source: Field survey 2016

Development and Maintenance

The development and maintenance usually commence during the first days of the raining season to enable adequate trapping of runoff waters from gentle slopes.

Based on the measurements from the fieldwork presented in Table 9, the water availability in litres were used to test the hypotheses that there is no significant differences in water availability in Tafki between wet and dry season. The result of the t-test determined a t-value of -1.14 with degree of freedom (d.f.) of 19 and probability equals 0.270 which shows that there is nosignificant differences at level 0.05 in the water quantity in litres in *Tafki*between dry and wet seasons. This is because some sources during the physical measurement have some substantial quantity of water available during the dry season, like in Jurara town (Jurara District), Changanawo Fulani (Galdimari District), Lariye (Hanafari District), Kiran Fulani (DogonJeji), Jafurni (Jamaare District), among others.

This may have suggested the statistical suggestion presented in Table 9 below.

Indororo Practice (Rooftop Harvesting)

Description of the Indororo Indigenous practice

This involves trapping of rainfall from the rooftop during raining season. Majority of users of this practice makes use of their aluminum roof to capture water using drums, buckets and plastic containers while others using local made roofs like the thatch roofs which are mostly used by indigenous population are of disadvantage and can only rely on other runoffs practices mentioned above.

It was further revealed during the course of the study that the practice is not well organized in such a way that much water would be collected, what is in practice is the use of the inclined aluminum roofs in conjunction with containers placed on ground which are directly facing eaves of the roofs to trap dropping waters from the roof.

Quantity is determined by intensity of rainfall which could also be affected by velocity of wind during the raining season. The higher the intensity of rainfall, the much water is collected; also the higher the velocity of wind the possibility that little will be collected; the less, the more water is being trapped. The practice is solely dependent on the raining season. Based on the result of the t-test carried out on the 19 sampled sites, revealed a significant differences in water availability between dry and wet season with a t-value of -8.38 and a probability of less 0.001 at 18 degrees of freedom. The practice started in the late 80s when some house owners were able to afford aluminum roofs as ascertained from the in-depth interview conducted but only used by few people compared to majority who cannot afford the aluminum roofing. Rooftop harvesting, accounts for 9.25% of the respondents.

Characteristics of the Indororo Water Source

The practice involves used of inclined aluminum roofs with containers like drums, earthen pots, plastic and metal buckets which are placed directly on ground surface facing the frontal roof edges to enable trapping of water falling from the roof. The practice is only applicable during raining season of every year which further depends on the intensity of rainfall.

Development and Maintenance

No organized and considerable awareness on the practice development and maintenance. It is only carried out as a means of collecting additional water source for domestic and livestock consumption which is only possible with the existence of metal or aluminum roof which water cannot penetrate through compared to thatch roof which sucks and the phenomenon rainfall that occurs yearly (Field survey, 2016).

The significant difference in the water level between the five (5) studied districts was tested using one-way analysis of variance as shown in Table 10. The result of the test indicates a p-value of 0.585 which is greater than 0.05, indicating that there is no significant difference in the water level between the five districts. Despite variation of water level from the physical observation and data obtained, the statistical test suggested no significant variation at level 0.05 in the water level, perhaps, due to existence of one or two means of indigenous water management practice(s) which the indigenous practice as source of their water collection for their various water consumption.

Jigo Practice (Shadoof System)

Based on the information gathered from the in-depth interview conducted with the *Sarkinruwa* of Jama'are district, it was revealed that Jigo was practiced in the study area for over thirty(30) years ago which involved use of simple tools like woods and skin bag to draw water from either bingi, well or river to the irrigation field which is divided into rectangular shapes called *Gida* or *Fangali*(compartment bunds) of varying sizes which are bordered by grid channels use in distributing the water to the compartments. The distribution is been controlled by the farmer as the water flows with influence of gravity and force from the water flow.

CONCLUSION

Based on the study carried out, Indigenous water management practices was revealed to be beneficial to communities using them as either the only option or an alternative means of water generation for both domestic and livestock purposes. Despite the almost non coherence to agricultural productivity as determined from the study, the practices, if sustained will go a long way in ameliorating livestock water need in the future if sustainably planned and managed. Even though these practices are being constraint by climate change. Therefore, the indigenous water management practices identified; *lalalo*, *Tafki*, *Bingi* and *Indororo*, are crucial for the wellbeing of the users as alternative water supply source which must be advocated for its sustainability and integration with the introduced technologies for the betterment of the rural communities and socio-economic prosperity which in advance can lure the government toward policy formulation and encouragement of indigenous communities participation in future decision making.

Improvement of the indigenous practices is also paramount, like the *indororo*, its proper planning and organization will yield more water capture and storage and reduction in wastage of fallen water; the buffering of the runoffs and groundwater harvesting sources will lead to more water retention, erosion and flood control as well trapping of more water for the beneficial use and scarcity reduction which will result in more productivity.

RECOMMENDATIONS

In reference to all findings in this study, the following recommendations are considered.

i. It is recommended that the various sources identified in the study area to be buffered with shrubs and trees which are resilient to dry season like the neems, dense grasses, afforestation, shelter belt etc. These are to be planted 2metres away from the apex top of the gentle slopes with openings left at the runoff paths which should also be transected by short line buffers. This will reduce the frequent erosion, flood and as well create a micro climatic condition and may also reduce loss of the collected water from the effect of evaporation and increase the water retention capacity of the water sources.

ii. There is need to set policies and enforce regulations that will guide and control use of indigenous water management practices. This will assist in enforcement of controls and even sanctions if possible on law breakers and consequently prevention of land degradation and fostering environmental protection.

iii. It is recommended that the indigenous water management practices are sustained and promoted through research, enlightment campaigns, especially in rural settlements. This will impact positively in reviving some of the valuable indigenous practices that will also foster pride in the minds of the indigenous communities that their indigenous techs are considerable.

iv. There is need to improve in the use of the *indororo* practice by encouraging use of gutters in buildings and connecting to storage facilities to enable collection of much volume of water from the rain and prevent the wastage to open space. This should be incorporated into building design in an aesthetic way. The collected water can be use for various purposes and will last considerably.

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