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Integration of traditional ecological knowledge and western science in natural resources management in the Okavango Delta, Botswana

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Since time immemorial indigenous people (IP) utilised resources to meet their cultural needs. While the long-established utilisation of these resources modified land, however, the alteration was negligible with fewer detrimental impacts on the environment. The adoption of Western Science (WS) saw people shunning the traditional ecological knowledge (TEK), resulting in accelerated resources degradation. Utilising institutional bricolage theory, this study combined remote sensing, geographical information systems, literature review and survey data to examine land use and land cover (LULC) change in three villages within the Okavango Delta and the role of TEK in resources management with a special reference to vegetation, land and water. Results revealed a widespread conversion of land and related resources and also that the adoption of formal education and religions significantly affected the utilisation of TEK in the management of resources. The study concludes that TEK is vital and is crucial in the conservation of natural resources.

Key words: Indigenous, land use and land cover (LULC), Shakawe, traditional ecological knowledge (TEK), remote sensing, religion, water.

INTRODUCTION

There are promising chances of integrating traditional ecological knowledge (TEK) and Western Science in natural resources management regardless of the differences existing between the two genres of knowledge (Hoagland, 2017). On the one hand, TEK refers to the knowledge and beliefs held by indigenous people (IP) (Huntington, 2000) and on the other hand, Western Science (WS) is the knowledge that emanates

from established universal scientific principles (Horton, 1967). It is the knowledge derived from a series of experiments and observations under the auspices of scientists. Thus, TEK is a collectively owned body of practices, taboos, values and sciences, passed on from one generation to another, orally (Millar, 2018). It is complex, hidden and is understood better by the people themselves than by “outsiders”. Whereas WS relies on

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documentation as a medium of transmission, TEK is orally transferred from one generation to generation (Warren, 1996). Thus, TEK is knowledge inherited from ancestors and one generation is bound to utilise and transmit it to the next generation (Usher, 2000), and WS is knowledge generated from laboratories (Schwartz et al., 2004). Based on Berkes' study (2000) TEK is synonymous with indigenous knowledge (IK) as both refer to the information about the interconnectedness of the natural environment, IP and all other living and non-living components. This is the knowledge IP have inherited from their ancestors and are at liberty to transfer it to the next generation (Usher, 2000). Thus, IK is a unique type of knowledge to a given culture different from the knowledge generated by institutions of higher learning and private firms (Warren, 1996; Kolawole, 2015).

Based on Berkes et al. (2000) TEK is qualitative, unlike WS which is quantitative. While TEK is intuitive and holistic (Johnson, 1992), WS is purely rational and reductionist (Schwartz et al., 2004). According to Martin et al. (2010), TEK as a genre of knowledge regards the mind and matter as a single entity, unlike in WS where the two are treated separately. Therefore, TEK is a moral type of knowledge as opposed to WS which is value-free (Klubnikin et al., 2000). According to Mackenzie (2018), TEK is spiritual and WS is mechanistic. Also, TEK is characterised by a slow build-up of facts through trial and error while WS relies on experiments and systematic accumulation of facts. In the opinion of Berkes et al. (2000), in TEK the users generate the data themselves as opposed to WS where data is produced by a few individuals who are experts in scientific enquiry. The TEK is diachronic meaning it is based on data gathered over a very long period spanning into centuries as opposed to WS which is synchronic designating data gathered over a short period but on a large area (Williams and Hardison, 2013).

Literature has shown that a natural resource management (NRM) framework that ignores TEK is bound to fail (Tripathi and Bhattarya, 2004; Kapfudzaruwa and Sowman, 2009). Experiences have shown that sustainable NRM is complex and therefore requires a systems approach. In this regard, the systems approach denotes research that is interdisciplinary whereby bio-physical, socio-economic and cultural phenomena are jointly embraced to comprehend the intricate nature of human and natural resources nexus (Barr and Dixon, 1998). To solve the complex and interrelated nature of sustainable NRM, Tripathi and Bhattarya (2004) recommend community-based participation in resources management. The inclusion of IP in resources management is a valuable approach because the decisions made concerning natural resources can capture their expectations and aspirations. There is a consensus amongst scholars that TEK plays a

significant role on issues bordering local, national or perhaps international NRM (Menziés, 2006). This follows the realisation that WS alone contributes less to the development of local areas (Mercer et al., 2007). Based on Clark (1994) the depletion of natural resources is attributed to ignorance of the local culture. Thus, embracing TEK helps to preserve important skills and technologies that are crucial in mitigating the problem of natural resources depletion. Ogunbameru and Muller's (1996) opine that integration of WS and TEK has the propensity for complementing each other's strengths and weaknesses. Based on Tripathi and Bhattarya (2004) the systems approach calls for documentation and mapping of TEK to preserve the knowledge held by our forefathers – a unique form of knowledge. However, literature has shown that attempts to gather information from a wide range of IP are laborious, costly and time-consuming (Kajembe and Rutatora, 1999; Adam, 2007). The proper storage of TEK is crucial because it provides easy access to data for use by stakeholders, especially planners and policymakers. Thus, the integration of modern technology comprising geographic information system (GIS), remote sensing (RS) and TEK enhances information bordering the management of resources at a local area. GIS and georeferenced remotely sensed data have the propensity for creating maps that can easily be applied in natural resources management at local levels (Mercer et al., 2007). The spatial aspect of TEK facilitates its integration with WS in NRM at the local level and this enhances decision-making processes.

From the IP's perspective, everything within the natural environment is densely embedded with ideas and is full of meanings (Johnston et al., 2011). Human worldviews are full of meanings and every object or scenario created has a meaning encoded to it and land, vegetation and water are not an exception (Strang, 2008). The meanings attached to objects influence every interaction that people have with these objects and with each other. In this way, land, vegetation and water signify various qualities including as a form of livelihood sustenance, that evoke belonging and habitat for powerful spirits (Adolina, 2012). Consequently, the integration of TEK and WS is vital because the NRM framework that is deep-rooted in the cultures of a local community is potentially more sustainable (Jackson, 2017; Andolina et al., 2009). In indigenous communities (IC), vegetation and water are depicted through symbols and artefacts (Mooney and Tan, 2012). Values, beliefs and norms form the core of any culture and the NRM system must embrace such cultural attributes. They have to do with feelings about what is good or bad. Culture is the shared perceptions, behaviour and symbols conveyed from generation to generation through learning (Clifford, 1988). It is the way of life socially acceptable in a community. Literature has shown that to achieve sustainable NRM as an agenda for development, a balance needs to be found between

social and economic factors (Kolawole, 2009). The sustainable development concept aims at satisfying the needs of the present generation without jeopardizing the capability of future generations to meet their requirements (Jabareen, 2008). Thus, the sustainability concept entails managing resources to ensure perpetuity in the use of resources (Burger et al., 2001).

Vegetation and water are vital resources with economic, societal and spiritual functions (Blackstock, 2001). From literature, natural resources play a fundamental role in the life of IP (Strang, 2008, 2014). Failure to recognise the significance of culture in NRM, no sustainable solutions can be found (Nakata, 2002). This is because relations between people and their environment are embedded in the culture. The intimate relationship between natural resources and people should be explicitly considered in all decision-making processes. From a cultural point of view, how vegetation and water are conceived and valued determines how they are managed (Hens, 2006). It has been shown that imported management strategies that fail to take into consideration the local people's cultural values usually fail (Hens, 2006). This is because cultural diversity developed over time by local people contain a trove of sustainable practices and innovation that proved to be resilient. The objective of the study is to examine the nexus between traditional ecological knowledge also referred to as indigenous spatial knowledge and WS in the analysis of dynamics of land use land cover and change in the Okavango Delta in Botswana.

THEORETICAL FRAMEWORK

The underpinnings of this paper are based on Cleaver (2001)'s institutional bricolage theory, an offshoot of the mainstream institutional theory proposed by Elinor Ostrom in 1990. Cleaver (2002) argues that it is vital to understand what constraints enable people to behave in the way they do and consider such issues when crafting rules to guide the management of resources. Thus, the theory's main tenet is that there exists more than one institutional arrangement at the local level which are equally important in the formulation and enforcement of rules. Accordingly, sustainable, equitable and efficient NRM requires the integration of both local and national level rules in the management of resources. The theory underscores the joint utilisation of local and national institutions in NRM. The coexistence and interaction in a positive way of the two genres of institutions is a stepping-stone towards the neutralization of the contradictions existing between local and state institutions (Gondo et al., 2020). This paper argues that instead of embracing WS as the sole arrangement in controlling behaviour and decisions bordering resources utilisation, the best approach is a scenario where the perspectives of the local people and their experiences are reflected in

the rules and regulations of NRM.

METHODOLOGY

Profile of study site

The study sites comprise Shakawe (in the upper delta), Tubu (middle delta) and Shorobe (lower delta). There were four ethnic groups comprising BaSarwa, BaYeyi, BaHerero and HamBukushu in the study area. The remoteness of the sites offered a favourable place for studying the integration of TEK and WS in understanding the variables affecting LULC and NRM.

Study design

The main thrust of the investigation was to examine the integration of TEK and WS in understanding the dynamics of LULC change with a special interest in land, water and rangeland resources. Three aspects characterise the methodology. These include satellite image processing to identify the dynamics in resources over space and time, literature review and a cross-sectional approach. The cross-sectional design approach was adopted because the method enabled data collection as a one-time event (Mthembu et al., 2016). This helps because in a cross-sectional design there is no need for further investigation. Thus, the process is inexpensive (Garn et al., 2018) and a literature review approach helps to widen the scope of the integration of TEK and WS. It also helps to determine what is known on the topic of interest (Rojas-Lema, et al., 2021), how well this knowledge is established and where future research might best be directed (Rozas and Klein, 2010).

Sample size

In this study, the random sample was made up of the listed 2011 census households in three villages of Shakawe, Tubu and Shorobe which was updated to incorporate new households that could have emerged after the 2011 census. Enumeration area (EA) maps for the 2011 national census were used to verify the number and location of all households in each of the villages. The sampling frame was all the households in the three villages which were randomly selected from all the villages in the Okavango Delta. The total number of households (HHs) in the three villages was 1669. To determine the sample size of HHs for each village, the number of HHs of each village was used as the population. Then the total HHs sample size for each village was calculated using the *Taro Yamane* formula with a 95% confidence level. Substituting in the formula the sample size of HHs for each village was obtained as Tubu 91, Shorobe 55 and Shakawe 315 and the results are tabulated in Table 1. The Taro Yamane formula is shown below:

$$n = \frac{N}{1 + N(e)^2}$$

Where: n= sample size; N = number of people in the population;(e) allowable error

Data collection

Data was collected using interview schedules, key informant guides and a review of related literature. The interview with village chiefs

Table 1. Population and sample size of each village in Okavango Delta.

Village	Population	Mean HHs	Sample HHs
Tubu	626	118	91
Shorobe	1031	64	55
Shakawe	8350	1487	315
Total	10 007	1669	461

Source: Author

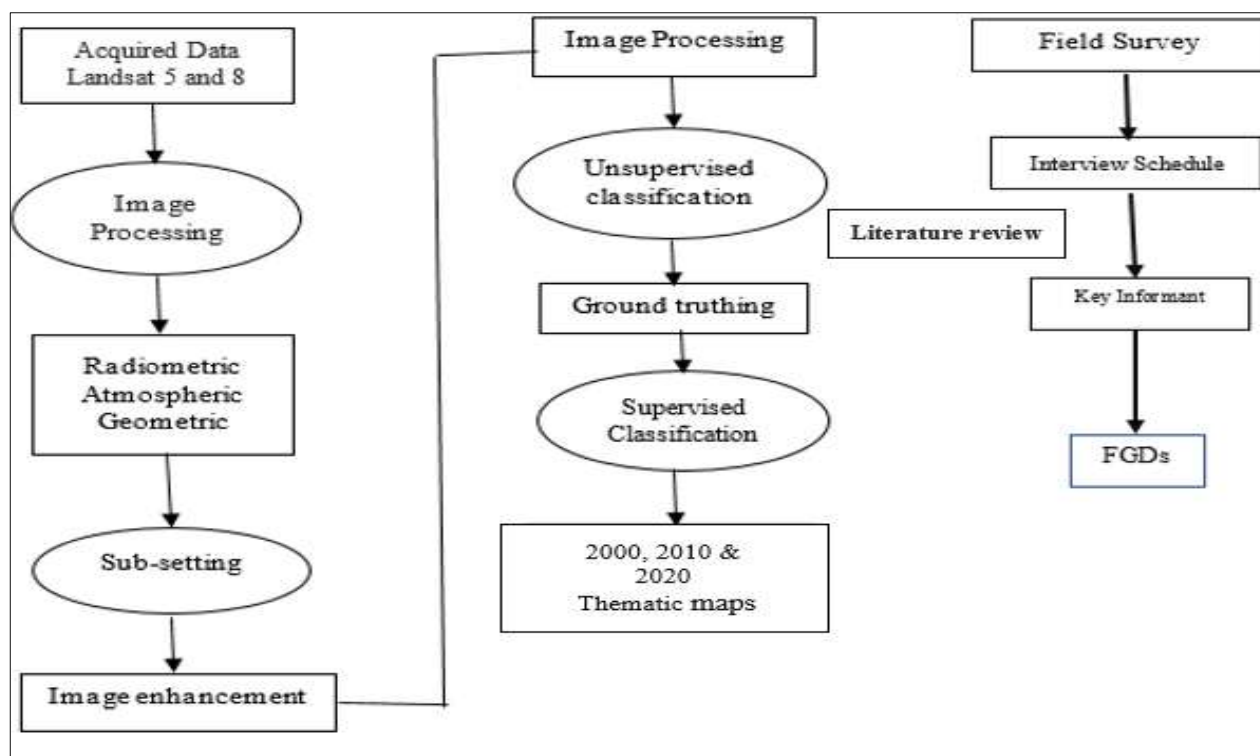


Figure 1. Methodology summary.
Source: Author

(dikgosi) and elders enabled key topics to be discussed. Thus, enabling the investigator to gain further insights into how TEK and WS knowledge can be integrated into the management of natural resources in the study area. Figure 1 is a summary of the key aspects of the methodology.

Data were gathered in two stages. Firstly, satellite images were downloaded freely from the United States Geological Survey (USGS). These images were processed using Quantum Geographical Information system 3.2 (Q-GIS 3) and ArcGIS 10.8. Processing involved radiometric correction - done to improve the fidelity of the brightness value magnitude (Wang et al., 2021), atmospheric correction conducted to remove the effects of the atmosphere on the reflectance values of images (Hadjimitsis and Clayton, 2008) and geometric correction, a process to transform the coordinates and dimensions of a remotely sensed image to eliminate spatial distortions in the original image (Wang et al., 2021). This was followed by image subletting, implying a process of extracting only the region of interest. Following this was image enhancement meaning a process of improving the quality and

information content of the original data before processing. Lastly, image classification to produce a thematic map as shown in Figures 3-5 was done. Five LULC namely open spaces, shrubs/trees, hydrophytes, water and built-up were generated from the classification process. The second part of the data collection process involved a field survey where four well trained degreed field assistants well versed in the Setswana local language were engaged. Data were gathered from household heads (HHs) and key informants interview schedules and FGDs.

While Figure 1 shows the methodology, Figure 2 is a map of the study area. Data was gathered from Shorobe Tubu and Shakawe in the lower, middle and upper delta respectively. The results section is organised into three major sections comprising the spatial analysis section where the spatio-temporal data from satellite images are analysed and maps produced to show the dynamics of natural resources from 2000 to 2020. This is followed by the discussion section, a section that draws much of the data from the literature, focus group discussions and interviews with the local people and the last section is the conclusion which summarises the

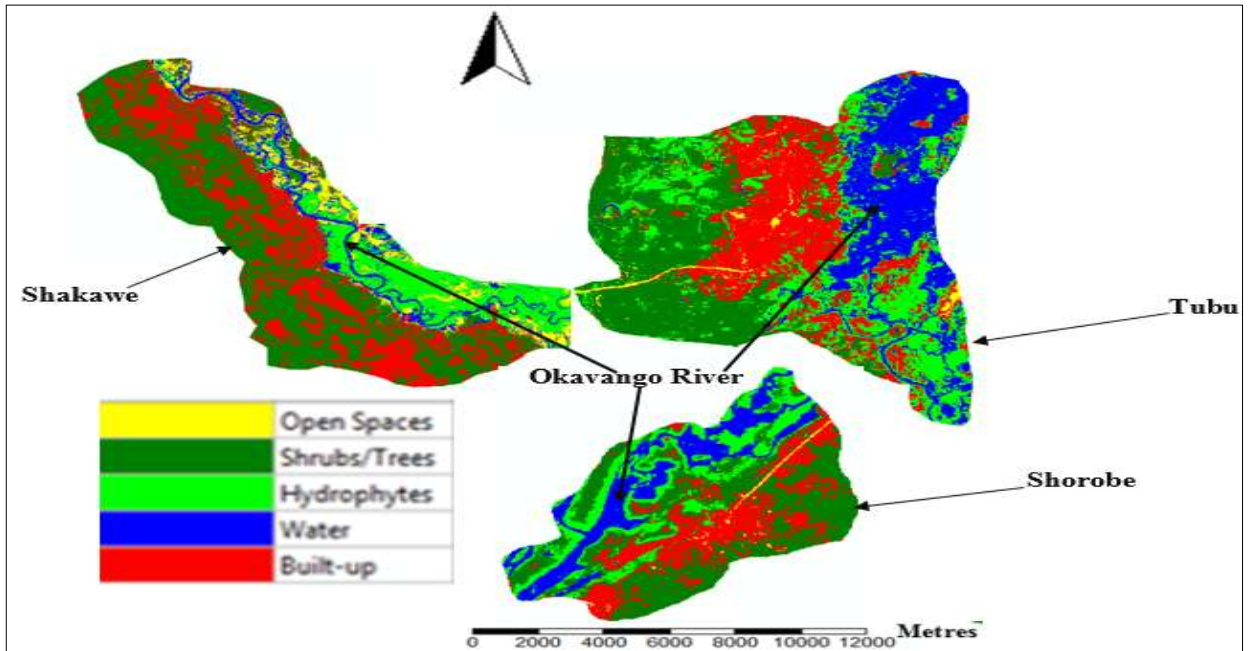


Figure 3. LULC in the study site in 2000.
Source: Author

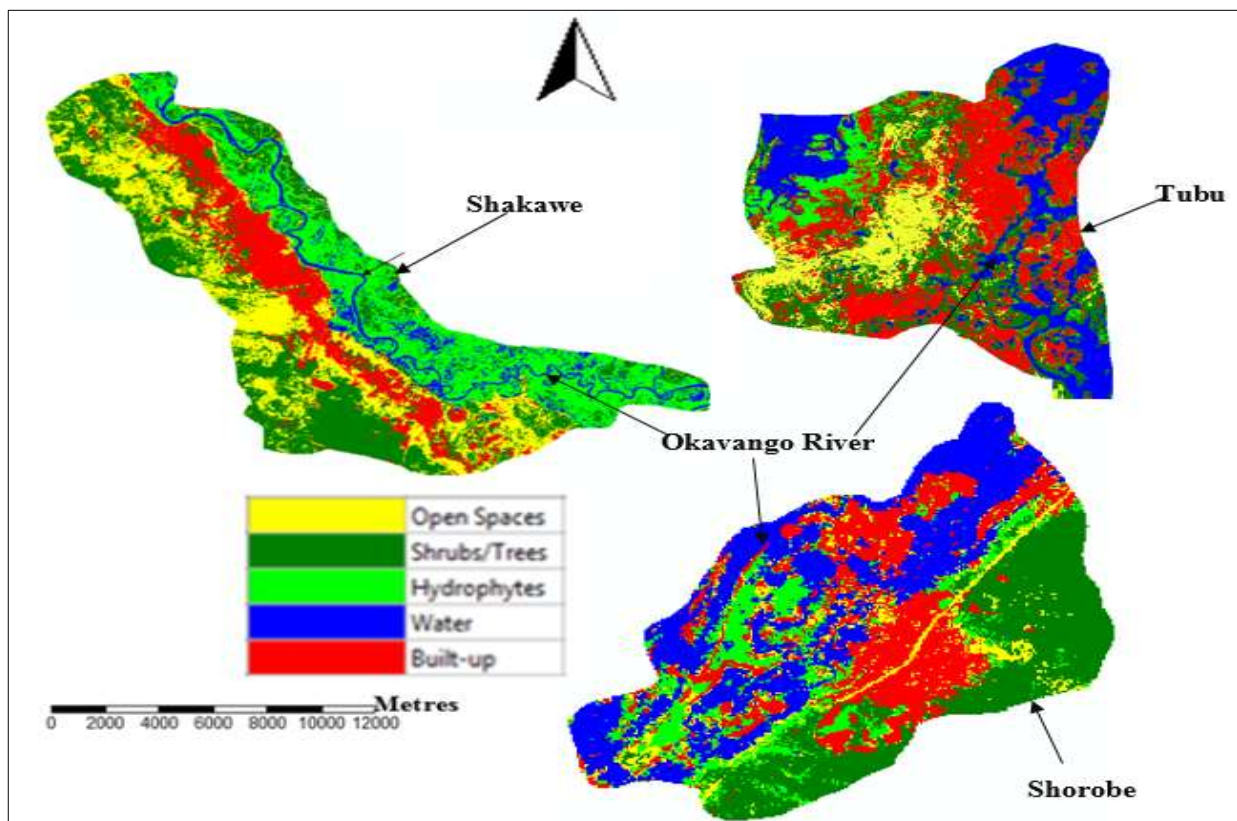


Figure 4. LULC in the three villages in 2010.
Source: Author

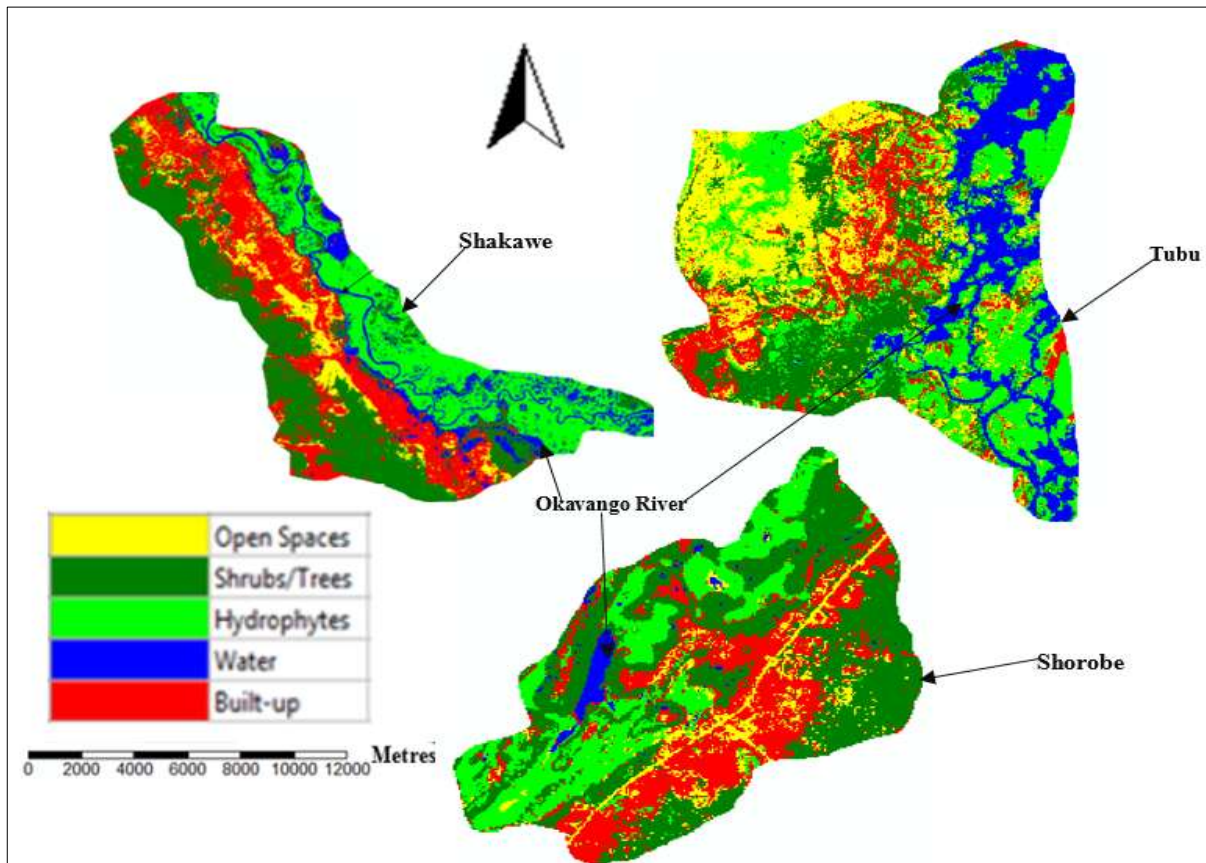


Figure 5. LULC in the villages in 2020.
Source: Author

Table 2. Land use land cover in 2000.

LULC	Tubu	Shorobe	Shakawe
Open spaces	5.5	16	95.9
Shrubs/Trees	65.7	78.3	96
Hydrophytes	3.1	48.8	76.7
Water	10.7	63.2	29.7
Built-up	10.9	52.6	30.7
Total	95.9	258.9	329

Source: Author

Table 3. Land use land cover in 2010.

LULC	Tubu	Shorobe	Shakawe
Open spaces	11.2	20.3	65.9
Shrubs/Trees	23.4	62.9	96.2
Hydrophytes	7	35.8	71.4
Water	25.9	79.3	19.5
Built-up	28.4	60.6	76
Total	95.9	258.9	329

Source: Author

Table 4. Land use land cover in the villages in 2020.

LULC	Tubu	Shorobe	Shakawe
Open spaces	10.1	11.2	57.8
Shrubs/Trees	18.9	45.7	66.1
Hydrophytes	15.0	37.5	27.3
Water	6.7	18.5	28.2
Built-up	45.2	146	149.6
Total	95.9	258.9	329

Source: Author

Table 5. Distribution of respondents by gender (n = 455).

Gender	Shorobe (%)	Shakawe (%)	Tubu (%)	Total (%)
Male	4	25.1	8.1	37.1
Female	9	43.9	9.9	62.9
Total	13	69	18	100

Source: Fieldwork, 2019

Table 6. Distribution of respondents by age group (n=455).

Age group	Frequency	Percentage	Descriptive Statistics
20-29	121	26.6	
30-39	112	24.6	
40-49	85	18.7	M = 42.5
50-59	63	13.8	SD = 16.2
60 +	74	16.3	
Total	455	100	

Source: Fieldwork, 2019.

The distribution of respondents by gender is shown in Table 5 which shows that the least (4%) male respondents were from Shorobe and most (25.1%) of them were from Shakawe. Tubu contributed only 8.1 percent of the male respondents. In total 37.1 percent of the respondents were males.

The highest (43.9%) female respondents were from Shakawe and Shorobe and Tubu contributing 9 and 9.9 percent of the female respondents respectively. In this study, the majority (62.9%) of the respondents were females and males constituted only 37.1 percent.

The findings show that the mean age of the respondents was 42.5 years with a standard deviation of 16.2 years. While the least (13.8%) respondents were within the 50-59 age group, most (26.6%) of them were in the 20-29 age group. The 60+ age group constituted 16.3 percent of the sample and 18.7% of the sample was within the 40-49 age group (Table 6). The 30-39 age group was second from highest constituting 24.6 percent of the sample size.

In terms of ethnicity, the majority (78%) were BaYeyi

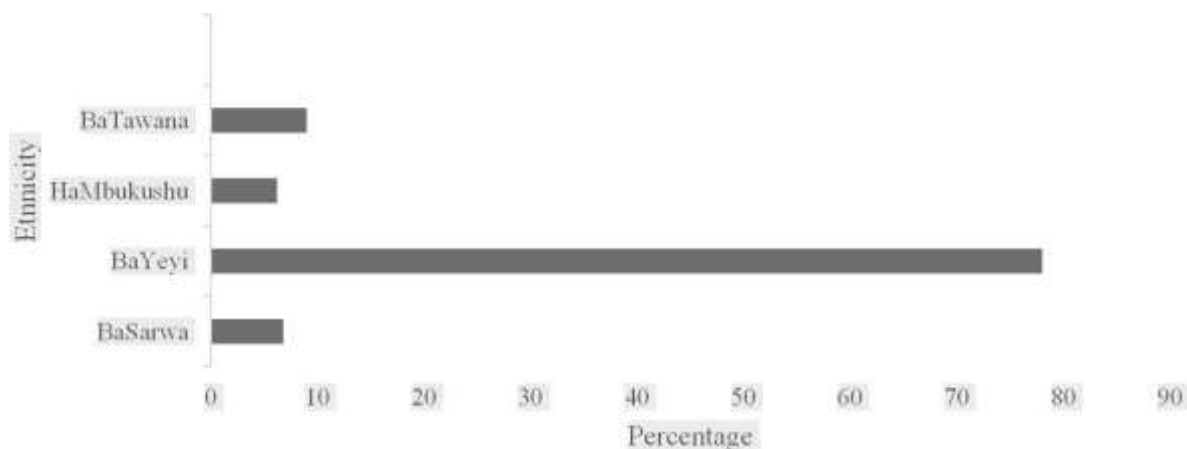
and the least (6.2%) were HaMbukushu. The BaTawana and BaSarwa comprise 9 and 6.8% of the sample respectively. The findings show that the majority (59.6%) of the respondents strongly agreed (35.4%) and agreed (24.2%) with the assertion that “[T]here are taboos for natural resources management (NRM)” within the Okavango Delta (Table 7). While 8.1% were neutral (U) and therefore decided not to reveal their opinions, 32.3% of them either disagreed (16.3%) or strongly disagreed (16%) with the statement on the availability of taboos for NRM. Concerning “[T]aboos are set and enforced by elders”, the majority (69.2%) of the respondents either disagreed (38%) or strongly agreed (32.2%) with the assertion. The results show that only 20% of the respondent concurred with the statement that “[T]aboos are set and enforced by elders” and 10.8% were neutral and therefore did not share their opinions (Figure 6).

Findings show that 54.5% of the respondents strongly agreed (29%) and agreed (25.5%) that “[S]anctions are imposed on those who violate taboos” (Table 7). While 15.5% of the respondents were neutral, 29.9% of them

Table 7. Respondents' disposition on NRM taboos (n = 455).

Statement	SA (%)	A(%)	U(%)	D(%)	SD(%)
There are taboos for NRM	35.4	24.2	8.1	16.3	16
Taboos are set and enforced by elders	12.1	7.9	10.8	38	31.2
Sanctions are imposed on those who violet taboos	29	25.5	15.6	14.1	15.8
Taboos monitor abuse of NR	34.9	26.6	14.5	11.4	12.6

SA = Strongly Agree; A = Agree; U = neutral; D = Disagree; SD = Strongly Disagree.
Source: Fieldwork, 2019.

**Figure 6.** Distribution of respondents by ethnicity.
Source: Fieldwork (2019).**Table 8.** Taboos relating to natural resources management.

Taboo	Outcome	Key informants' comment
Cutting down trees	Becomes insane	To avoid soil erosion
Gathering wild fruit for sale	Gets lost	Curbing overexploitation of wild fruits
Entering sacred places	Taken by mermaid	To key ecosystems intact
Fishing in sacred places	Taken by mermaid	To preserve fish breeding areas
Washing in river	Taken by mermaid	Curb water pollution
Streambank cultivation	Taken by mermaid	Curb siltation

Source: Fieldwork, 2019.

either disagreed (14.1%) or strongly disagreed (15.8%). The results also show that the majority (61.5%) of the respondents strongly agreed (34.9%) and agreed (26.6%) with the statement that "[T]aboos monitor abuse of natural resources (NR)". While 14.5% of the respondents were neutral, 11.4% and 12.6% of them disagreed and strongly disagreed respectively.

Findings show that taboos on water, land and vegetation were meant to ensure the sustenance of natural resources. The outcome of violating a taboo was either one goes mad or disappears by being taken by a

mermaid (Table 8).

Concerning the question on water creatures regarded as the most important symbol of water, the findings revealed that the majority (52%) of the respondents viewed frogs as the most crucial symbol for water (Figure 7). The least (2%) respondents associated water with the shark (1%) and whale (1%). While 4% of the respondents linked water with fish, 15% of them viewed snakes as the symbol for water in the villages. Crocodiles, seashells and birds contributed 12%, 5% and 10% of the respondents respectively.

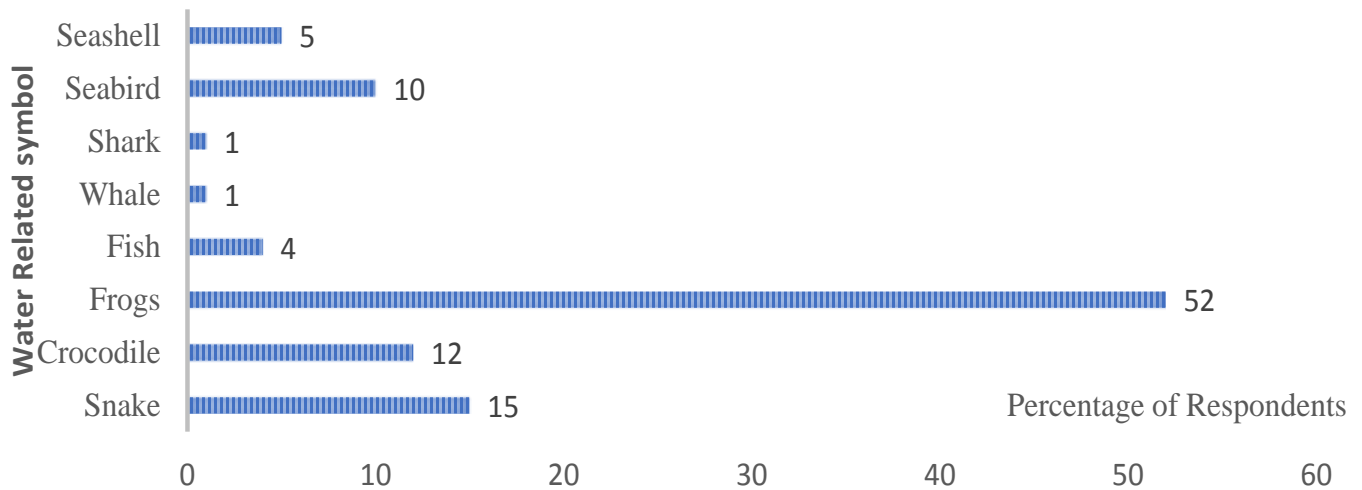


Figure 7. Disposition of respondents on Water symbols (Source: Field survey, 2019).

DISCUSSIONS

The results revealed that the conservation of natural resources in the study area utilised taboos among other indigenous means. A taboo is any ritual prohibition on certain activities which may involve the avoidance of certain places, objects or actions (Mapira and Mazambara, 2013). A personal interview with a key informant revealed that some places were regarded as sacred and were not supposed to be ill-treated by human activities. The key informant had to say, “[a]ny person who enters a sacred place risked disappearing, eaten by wild animals or become insane in the forest”. It is important to note that the consequence associated with entering sacred sites might not be true, however, it is equally important to note that such taboos were meant to ensure a harmonious relationship between people and vegetation. Thus, a taboo preventing people from cutting down trees implicitly inform local people to regard vegetation as part of human beings than adopting the homocentric ethics whereby only the welfare of people has intrinsic moral worth (Velasquez and Rostankowski, 1985). In this way, taboos were a way to protect vegetation and land resources against possible anthropological damage. Consequently, land and vegetation were kept in their natural state for centuries without being degraded by human interference. An analysis of the taboos to conserve vegetation, in general, revealed that taboos were protecting fruit trees, medicinal as well as those trees along watercourses. Fruit trees were regarded as home for the ancestral spirits. During an FGD one elderly man had to say, “[t]rees and water bodies are the dwelling places of our ancestors and therefore should not be cut and polluted”. This finding is similar to the results of a study by Sarfo-Mensah and

Oduro (2007) on the role of customary rules in the management of natural resources. The study found that elderly people in Ghana believed that spirits and gods of their area live in trees and pools of water and in turn, no one is permitted to cut trees and make the water dirty. Thus, taboos were enshrined in religious and cultural beliefs and were enforced by prohibition. It is noteworthy that while taboos had no legal backing, they are so strong that local people obeyed them.

A study by Codjoe (2007) in Ghana on LULC also produced five classes and showed that people used taboos in the conservation of resources. Land and vegetation are crucial assets and means to sustain livelihoods especially in indigenous communities (Codjoe, 2007). In wake of the rapidly growing population, increase in technological capacity and affluence in the Okavango Delta, the land cover was transformed since 2000 as indicated in the maps in Figures 3-5. The decline in vegetation cover is attributed to the increase in human population which demand more space to build houses. As more shelter was constructed more vegetation cover was cleaned as result. This implies that sacred places were cleared of vegetation cover and people could no longer regard such places as sacred. This concurs with Das et al. (2020) who opine that competition for space results in people utilising sacred places with the consequence of the sacredness of such places being undervalued.

Across various cultures, the frog serves as a symbol of water, usually associated with the local deity (Akpabio, 2012). Literature has shown that the association between water and frogs has developed independently in many societies rather than being a result of outward diffusion from a single cultural source (Drewal, 2008). Like in other cultures as noted in the literature, water is a valuable

resource in the study area. Besides being crucial for human beings, water is also important to nonhuman beings such as vegetation and animals. Thus, the findings also revealed that there were taboos relating to the management of water resources.

It is noteworthy that the belief system in the local communities in Africa and perhaps elsewhere prioritise utilisation of indigenous to western science. Thus, the results of this study point to the fact that the belief system of the people within the study area can protect natural resources and the environment in general if the local people have an interest in them. Based on Shastri et al. (2013)'s study indigenous communities use their indigenous knowledge to observe environmental ethics that help in regulating their interaction with the natural environment. Through indigenous knowledge, local people in the OD have vital cultural practices and belief systems that are environmentally friendly and sustainable, thus, contributing to natural resources sustainability. A discussion with key informants as well as heads of households shows that local people hold the ascription of supernatural powers to objects. This concurs with Rim-Rukeh et al. (2013) who reiterate that the local communities' belief system lies in the abode of the gods located in water, vegetation and land and such belief system is respected by the local people. Like in Ghana indigenous knowledge is the prime factor guiding people's conduct towards the exploitation of natural resources in the study area. A key informant had this to say about the role of western science in the management of natural resources: "*Western science in the form of Christianity and modernisation has worn away our indigenous knowledge and belief system in the management of natural resources*". A further probe to understand how western science has helped in the erosion of indigenous knowledge the key informant had to say: "*Our knowledge system is eroded through acculturation of local people especially through the introduction of Christianity and the sudden rise of the tourism industry in the Okavango Delta*". Culture is not static but is ever evolving and all traditions and beliefs are likely to be changing over time. As people in the Okavango Delta reflect global trends of increased movement and communication between communities such change is expected to accelerate. The key informants thus were worried about the migration of people in and out of the Okavango Delta and thought that the degree to which rules and regulations bordering natural resources management are respected is to a greater extent influenced by western science than with the indigenous knowledge. Therefore, the findings of this are like the findings of a study conducted by Lingard et al. (2003) who found that migration of people has a propensity to dilute the local culture. Thus, many people perceive foreigners as immune to local rules and norms, but once they are regularly broken, local adherence is

also likely to reduce. In this regard, people who at first are reluctant to break the taboo soon do so willingly.

The adoption of other religions outside the African Traditional Religion (ATR) was also noted as the reason why the importance of local rules was losing value in the study area. An informal interview with the elders revealed that local rules were no longer effective as their efficacy in the management of resources were altered with a change of time. The elders bemoaned that several people especially the youths and foreigners knowingly break the rules because they regard them as baseless. From the informal interview with the local elders, it was noted that modern forms of education together with foreign religions influenced the current degradation of local rules in the management of resources especially concerning compliance to taboos. Thus, from the perspective of the elders, it is the current forms of education that diminish the belief in the importance of taboos. It was also revealed that elders complying with foreign religions could not transmit TEK to their children. This was particularly common amongst people who were non-indigenous to the Okavango Delta. Despite the rebuffing of local rules by the educated young generation, the old generations regarded taboos as very relevant in the management of natural resources. The study revealed that water continues to hold several meanings that serve to highlight the human natural phenomenon nexus. From the results, two interconnected issues were emphasized. On the one hand, perceptions and engagements with water in the study area were shaped by spiritual insights and on the other hand, such wisdom borders on the existential matters which necessities need for cultural regulatory practices such as taboos, norms and values in the utilisation of natural resources. This is because water personifies godness and local people regard it as therapeutic as well as life (Bowles, 1993; Gondo et al., 2020). Such a belief is in line with Lingard et al (2003) who opine that the knowledge of water conservation is shaped by contexts of the cultural and social factors.

Since pre-colonial times, IKS in natural resources management has been part of Africa's heritage. IKS aims to address local challenges bordering natural resources utilisation and management. This form of knowledge is locally oriented and has stood the test of time (Akena, 2012). However, western science which is packaged in the form of western education and religion has destroyed or marginalised the desirable IK and replaced it with western knowledge and approaches (Mapira and Mazambara, 2013). In line with Mapira and Mazambara (2013) the position of this paper is that local people in the Okavango Delta were concerned about their belief system which has perpetuated Okavango Delta and its environments in a pristine state for centuries. This implies that no one could mismanage the natural resources and environmental settings for centuries. Based on the

participant during FGDs, “the *punishment that was in place for people who mismanage natural environment was so severe that local people were mindful of the utilisation of the available resources*”. In this regard, certain areas such as forests, water points and rivers were revered and therefore sacred to be abused. The belief system has to a larger extent contributed to natural resources management and has also played a key role in ensuring that people who broke rules and norms are punished. However, on the contrary, western science and its devotees argue that the reason why local communities in Africa and elsewhere in the developing countries did not develop is that they are living in primitive environments and lack innovative thinking, technology and the ability to advance (Weiss et al., 2013). It is noteworthy that whether indigenous people and their knowledge live in ignorance at least they need to be given applause for leaving the Okavango Delta and its locality undestroyed for prosperity. In this regard, the positionality of this paper is that sustainable equitable and efficient management of natural resources requires a firm commitment to institutional pluralism. This approach emphasises the joint utilisation of WS and IKS in the management of natural resources. It is from this vantage point that it is argued in this paper that while WS is vital in the management of resources, there is also IKS which is equally important in the management of natural resources. This is in line with the institutional bricolage theory which acknowledges the existence of more than one institutional arrangement at the local level and which can generate and enforce rules. Based on the interview with the key informants as well as interactions with local people during FGD, western science through formal education and Christianity have a lot to blame for causing undesired alterations to natural resources in the OD, Botswana and perhaps in Africa. This concurs with Diawuo and Issifu (2015) who also regards western science as the major contributor in changing local people’s belief system. Also, Appiah-Opoku and Hyma (1999) reiterated that before colonisation indigenous people entrusted all-natural resources management in their belief system. Thus, before colonisation elders and chiefs occupied a unique position in the management of natural resources. They were accepted by their people as the custodian of religions, spiritual embodiment of their communities with the responsibilities of managing and holding the trust of both natural resources for the dead and the living.

Conclusion

The study aimed at mapping land use and land cover changes and comprehension of traditional ecological knowledge in natural resources management in three villages within the Okavango Delta. Five land use and land cover were generated for a ten-year interval from

2000 to 2020. Evidence from the thematic maps revealed a reduction in vegetation cover and an increase in the built-up area. Findings also reveal that preference was given to WS than indigenous knowledge systems. This is despite that sustainable management of resources is better achieved through the utilisation of both genres of knowledge systems. It has been noted that traditional ecological knowledge is vital in natural resources management and the study calls for the inclusion of this type of knowledge in NRM. This is because traditional ecological knowledge is peculiar to the local area and it saves the needs of the locals ultimately their natural resources. The study recommends an in-depth study of the symbols bordering rangelands and water in various ethnic groups. It is also recommended that policymakers need to ensure that traditional ecological knowledge forms part of the education system within the country. Thus, there is a need to include TEK in primary, secondary and tertiary education curricula within the country.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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