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Akosombo Dam Spillage: A nightmare that needs no repeat but re-strategising

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Abstract

Ghana's largest source of hydroelectric power supply comes from the Akosombo Dam in the Volta Region. Neighbouring countries such as Benin and Togo have equally benefited from the power supplies from this dam. Unfortunately, due to climate change and other domestic factors, it is becoming challenging for managers of the dam to accurately predict the water levels and the impact of spillages. Although the most recent spillage was underestimated, it has been very destructive, with devastating consequences, leading to the loss of belongings and livelihoods as communities were totally swept away. Using a team of experts and a desktop review approach, this policy brief investigates the effects of the dam spillage and suggests relevant policy directions for addressing them.

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Introduction

On September 15, 2023, the Volta River Authority (VRA) initiated a controlled dam spillage as a preventive measure to avoid water levels reaching a critical point and jeopardising Ghana's oldest and largest hydropower facility. While this exercise has been deemed a "necessary evil" by many, it effectively safeguarded the dam from potential damage. Regrettably, it also resulted in substantial disruptions in livelihoods, displacements, and property losses. This paper shares perspectives on impacts, prescribes solutions, and discusses the way forward for Ghana.

Gender and vulnerable groups

Dams are crucial for water resource management, the generation of energy, and the mitigation of floods. However, it is important to acknowledge that occurrences like the Akosombo Dam spillage may carry adverse social, economic, and environmental repercussions, particularly impacting women and other marginalized communities. Hamidazada et al. (2019) identified in their study that flood disasters tend to inflict a disproportionately traumatic toll on vulnerable demographic groups, specifically children, women, and the elderly. Armah et al. (2010) found that the release of excess water from the Bagre Dam in Burkina Faso had a disproportionate impact on specific groups, such as childless widows, the elderly, and children, who were more vulnerable to experiencing harm, losses, and distress in Northern Ghana. This finding draws parallels to the spillage incident of the Akosombo Dam. The vulnerability to floods is connected to gender, with women often bearing a greater burden of familial caregiving responsibilities due to their roles (Walker & Burningham, 2011; Naz & Sadiq, 2021), especially in societies such as Ghana where these responsibilities are traditional. Female-headed households, according to Gaisie et al. (2022), encounter heightened challenges in managing and recuperating from flood events due to entrenched gender norms, bigger household sizes, caregiving roles, fewer employment opportunities, and limited resource accessibility. Efforts aimed at mitigating floods should integrate gender-inclusive strategies within flood preparedness initiatives, taking into account the distinct needs and susceptibilities of both women and men.

Livelihood, poverty and development

The spillage of the Akosombo dam has had a series of devastating effects on the lives of residents in the affected areas. The livelihoods of most of these residents have been destroyed. Their businesses and sources of daily income have been washed down the drain. Most of the residents are farmers who engage in fish farming and crop production. Studies from some of the community members who have experienced previous spillage indicated that about two-thirds of the residents had their livelihoods worsened after the construction of the dam due to the spillage (Armah et. al., 2020). Most people had their livelihoods displaced, with the greatest hit being the fish farmers. Given the significant population growth in the area over recent years and the devastating impact

of the spillage on lives and properties, it is undoubtedly clear that the 2023 dam spillage is the severest ever experienced in the region. It is reported that about 26,000 people have been displaced and are still counting. These people have lost their jobs, become worse off, and are surviving at the mercy of others. Khayyam (2020) asserts that the displaced livelihoods of these residents tend to deepen their poverty situation, impede the development of their communities and the country at large, and require critical attention.

Pollution and public health

The flooding due to the spillage of the dam poses significant public health concerns about the health and wellbeing of inhabitants of flooded and displaced communities. Floods displace pollutants from agricultural activities, including fertilisers, animal waste, weedicides, and pesticides, which infiltrate drinking water sources such as rivers, streams, and wells, consequently resulting in contamination. Individuals who consume water from these polluted sources may experience poor health due to the elevated levels of phosphorus and nitrogen in pollutants originating from agricultural activities. High consumption of nitrogen is linked to an increased risk of colorectal cancer (Ward et al., 2018), thyroid disease (WHO, 2016), and methemoglobinemia (Brender, 2020). Also, floods have the potential to transport both solid and liquid waste (such as faecal matter) originating from households across different communities, posing a risk of contaminating drinking water supplies and compromising human health. Studies have linked the ingestion of faecal matter by humans and animals with various illnesses, including infections, Cholera, Hepatitis E, Typhoid Fever, Dysentery, and Diarrhoea (Gupta & Agarwala, 2018; Mensah et al., 2018; Majorin et al., 2019; Eurien et al., 2021). Interventions to mitigate the public health implications arising from the flooding should include the provision of potable drinking water for flooded and displaced individuals to reduce their risk of water-borne diseases, including but not limited to Diarrhoea, Cholera, and Dysentery.

Farming activities and food security

Farming activities along river basins have been noted to contribute to food security due to all-year-round access to irrigation sources (Passarelli et al., 2018). The Volta Basin contributes significantly to food security in Ghana, as almost all rice cultivation in Ghana is carried out within the Volta Basin catchment. Based on a 3-year average data spanning from 2016 to 2018, as reported by the Ministry of Food and Agriculture (2019), the Volta Region maintains its prominent position as the primary paddy rice producing region in Ghana. It accounts for approximately 37 percent of the country's total production. Communities around the Akosombo Dam are noted for the cultivation of rice, maize, cassava, and bananas. There is also a great level of commercial fish farming activity in the Akosombo Dam enclave (Ragasa et al., 2020). With the spillage of the Akosombo Dam, several farms are flooded, and crops will be lost. Several fish farmers have also

lost their cages of fish. While these have a direct financial effect on the farmers, the implications for food security are enormous. The loss of food will directly affect food availability. Further, the loss of food will result in food supply shortages, and this will result in high food prices as demand exceeds supply. This will affect access to food. Affected farmers in these communities are less likely to take up farming in the future even when compensated, and this will affect food stability in the long run. Beyond compensation, farmers need counselling and education on farm insurance to ensure they remain in the business of farming.

Education and awareness

A dam's limited capacity has serious repercussions. That is, downstream populations, infrastructure, and the ecosystem are at risk of flooding (Castro and Rifai, 2022; Ntiamoa-Baidu et al., 2017). Additionally, a spilled dam may sustain physical harm, which could jeopardize the dam's structural integrity (Sun et al., 2022). Efforts must be made to prevent dam spillage through careful monitoring of water levels and controlled releases when necessary (Richter and Thomas, 2007). In eventuality, education and awareness creation about the spillage of the dam are crucial for the safety and well-being of communities living downstream, especially in the event of the spillage of Akosombo Dam (Ntiamoa-Baidu et al. 2017). There are several mediums to adopt in this education and awareness creation, as done all over the world. Development of brochures, posters and educational materials in multiple languages spoken in the affected communities that vividly explain the potential risks associated with the Akosombo Dam and what to do in the event of a spillage or emergency as it has occurred in recent times. Another equally important medium is to organize workshops and seminars in the communities downstream of the dam to educate residents about the dam's operations and the potential risks and dangers involved. Partnering with local radio and television stations to broadcast public service announcements about dam safety and spillage risks is also important. Local schools and universities can also incorporate information about the dam and spillage risks into their curricula. Holding regular community meetings to discuss dam safety, emergency response plans, and evacuation procedures are paramount educative measures. Finally, creating a website and using social media platforms to disseminate information should be considered.

Interventions and policy direction

Since the inauguration of Ghana's largest hydroelectric dam, near a Diamond Jubilee ago, with its associated intermittent spillage management methods, it is unclear what the public policy and control mechanisms that guides these processes are. The most recent devastating impact and lack of responsibility calls for a clear public policy to aid the management and possible impacts of the process. To achieve this, collaboration is vital among management entities, including the Volta River Authority

(VRA), National Disaster Management Organization (NADMO) under the Ministry of the Interior, Ministry of Sanitation and Water Resources (MSWR), Water Resources Commission (WRC), Ghana Water Company Limited (GWCL), Ministry of Local Government and Rural Development (MLGRD), Media outlets, as well as other private and public sectors stakeholders. Their concerted efforts must be directed towards delivering aid that genuinely addresses the needs of affected communities, beyond political interests. It is imperative that these organizations, along with government authorities, employ real-time data to target the root causes of disasters and re-strategise to prevent recurring scenarios. Key necessities for women, children, "physically unabled" and other vulnerable populations encompass warm meals, blankets, sanitary products, mosquito nets, water purification facilities, and suitable shelter, such as tents placed on elevated ground. To achieve sustainable solutions, government institutions must prioritise robust spatial planning in the impacted regions. A collective effort is needed to reconfigure these areas, adapting them to the new realities brought about by the effects of climate change. It's essential to consider a spatial reorganisation that can divert a portion of the water spillage for both commercial and domestic purposes. As the challenges of development evolve over time, our spatial infrastructure should be made flexible and prepared to address the global issues posed by climate change.

In conclusion, the recent Akosombo Dam spillage was indeed a nightmare for many, disrupting lives and property in its wake. While it served its primary purpose in safeguarding the dam and preventing a potential catastrophe, it also revealed the urgent need for a comprehensive re-evaluation of our strategies. As we reflect on the damage caused and the lives disrupted, it is imperative that we embrace this opportunity to learn from our experiences and develop better, more sustainable methods for safeguarding our vital infrastructure. We must prioritize the protection of our communities while ensuring that we do not compromise the lifelines of our nation. It is through this combination of vigilance, strategic planning, and collective efforts that we can transform this nightmarish episode into a catalyst for a more secure and resilient future.

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Prevalence and determinants of Internet use among reproductive-aged women in Ghana: Analysis of the 2021 Ghana Population and Housing Census

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Abstract

This study analysed the prevalence and determinants of Internet use among reproductive-aged women in Ghana using data from the 2021 Ghana Population and Housing Census, involving 811,022 women. It found that 75% of these women used the Internet within three months before the census, with mobile phones being the primary access device (74.6%). Significant determinants of Internet use included age, education, religious affiliation, marital status, residence, ecological zone, wealth, and employment status. Specifically, religiously affiliated women, those living in the Middle belt, and those employed were more likely to use the Internet, while women in rural areas and the Coastal belt were less likely to use Internet. These findings highlight the need for targeted policies to promote Internet use among Ghanaian women of reproductive age.

Keywords: Internet use, women, reproductive age, determinants, Ghana

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Introduction

Internet use has become prevalent in the 21st century. Over time, there has been global growth in the percentage of the population utilising the Internet. For instance, the global population using the Internet has increased from 16% in 2005 to 67% in 2023 (International Telecommunication Union (ITU), 2024b). The percentage of the population utilising the Internet also varies across countries and regions worldwide. In 2023, the prevalence of Internet use was highest (91%) in Europe and lowest (37%) in Africa (International Telecommunication Union (ITU), 2024b). In Ghana, 69% of the population used the Internet as of 2021 (International Telecommunication Union (ITU), 2024a).

The utilisation of the Internet has both positive and negative impacts on individuals. Some studies have linked the use of the Internet to cyberbullying (Li et al., 2023), increased suicidal thoughts (Poorolajal et al., 2019), depression (Pang, 2021), distress (Mamun et al., 2020), reduced hours of sleep (Wang et al., 2022), and increased smoking and alcohol intake (Tao et al., 2017). However, Internet use has been associated with increased social participation (Austin-McCain, 2017; Lattie et al., 2019), enhanced access to health information and healthcare (Lattie et al., 2019; Okoye et al., 2021; Tariq et al., 2020), enhanced stress management (Saini et al., 2020), increased physical activity (Marquet et al., 2018), and mental health (Lattie et al., 2019).

However, studies have established that women are less likely to use the Internet than men (Baloğlu et al., 2020; Kannan et al., 2019; Schimmenti et al., 2021). According to the International Telecommunication Union (ITU) (2024a), more males (72%) in Ghana used the Internet than females (65%) as of 2021.

Studies that have focused on Internet use among women have shown mixed findings about women's prevalence of Internet use. For instance, Serçekuş et al.'s (2021) study in Turkey among 162 pregnant women found that 92.4% used the Internet to seek information about their childbirth. However, Kavlak et al.'s (2012) study in Turkey among 185 pregnant women found that 45% used the Internet at least once during their pregnancy. Also, Okunlola et al.'s (2023) study in Northern Nigeria among partnered women aged 15-49 found that 4.3% used the Internet. In Ethiopia, a study by Meshesha (2023) among reproductive-aged women found that about 5% used the Internet.

Studies have identified socio-demographic characteristics (such as women's age, educational level, marital status, wealth index, and region of residence, among others) and reproductive health behaviour (family planning) as significant determinants of Internet use among reproductive-aged women (Meshesha, 2023). Studies on Internet use have some limitations. First, few studies on Internet use among women have been conducted in sub-Saharan Africa (Ibegbulam et al., 2018; Meshesha, 2023; Okunlola et al., 2023; Wilson & Lawan, 2015). Second, few of these studies were conducted among reproductive-aged women and used nationally representative data (Meshesha, 2023; Okunlola et al., 2023). Third, few of these studies examined the determinants

of Internet use among reproductive-aged women (Meshesha, 2023).

To contribute to this knowledge gap, this study examined the prevalence of Internet use, the type of information and communication technology devices used to access the Internet, and the determinants of Internet use among reproductive-aged Ghanaian women using the 2021 Ghana Population and Housing Census. The 2021 Ghana Population and Housing Census data covers all women residing in Ghana, which will ensure that the findings of the study can be generalised to all reproductive-aged women in Ghana. This study's findings will help develop context-specific interventions to promote Internet use among women in Ghana. Promoting Internet use among women of reproductive age can enhance their access to healthcare information and services, especially those related to their sexual and reproductive health. Studies have shown that women in their reproductive ages use the Internet to access medical information on their health status (Kemp et al., 2019), and pregnancy-related information, including childbirth and the safety of medication during pregnancy (Bert et al., 2013; Serçekuş et al., 2021).

Materials and methods

This study used 10% of the Ghana Population and Housing Census data from the Ghana Statistical Service. The census data contain population and housing information about all individuals residing in Ghana. However, this study was limited to only Ghanaian women aged 15-49. The Ghana Population and Housing Census covers diverse issues, including socio-demographic characteristics, emigration, housing conditions, and information and communication technology.

The dependent variable for this study was measured by Internet use in the last 3 months preceding the census; the responses were yes and no. The independent variables were age (15-19, 20-24, 30-34, 35-39, 40-44, and 45-49), educational level (no formal education, pre-school/primary, Junior High School/Middle, and Senior High School and higher), and place of residence (urban and rural). Religious affiliation of women was reclassified as not religiously affiliated (no religion) and religiously affiliated (Christians, other Christians, Islam, Ahmadi, Traditionalist). Similarly, the marital status of women was reclassified as currently married (married and informal/living together), ever married (separated, divorced, and widowed), and never married. The 16 regions of Ghana were reclassified as ecological zones (Northern belt, Middle belt and Coastal belt). The Northern belt consists of Northern, Savannah, North East, Upper West and Upper East regions, while the coastal belt comprises Western, Western North, Central, Volta, Oti and Greater Accra regions. The Middle belt comprises Bono, Bono East, Ahafo, Ashanti and Eastern regions. The Middle belt consists of Brong Ahafo, Ashanti and Eastern regions. Women's status in employment was reclassified as unemployed and employed (employee, self-employed, casual worker, and paid apprentice, among others). The wealth index was computed for 19 household assets using the Principal Component Analysis method. The computation of the wealth index is documented in previous studies (ICF International, n.d.).

Descriptive statistics were used to describe the respondents' socio-demographic characteristics and information and communication technology devices used to access the Internet. Pearson's chi-square was used to examine the association between the respondents' socio-demographic characteristics and Internet use. Additionally, binary logistic regression was used to examine the determinants of Internet use among reproductive-aged Ghanaian women since the dependent variable was dichotomous. All variables were regarded as statistically significant at a 95% confidence interval.

Results and Discussions

Table 1, shows the socio-demographic characteristics of the respondents. Overall, 811,022 women were analysed for this study. One-fifth of the respondents (20.1%) were aged 15-19, while 7.7% were aged 45-49. Respondents aged 45-49 had the lowest internet usage rate (61.6%) compared to those in the other age groups (p-value = 0.000). Over one-third of respondents (37.5%) had attained Senior High School and higher education. Respondents who had attained Senior High School and higher education had the highest internet usage rate (97.1%) compared to those who had attained other educational levels (p-value = 0.000). Additionally, most of the respondents were religiously affiliated (97.4%) and resided in urban areas (60.8%). Most respondents who were religiously affiliated (75.5%) and resided in urban (84.5%) used the Internet, in contrast to those who were not religiously affiliated and resided in rural areas (p-value = 0.000). A greater proportion of the respondents were living in the Northern belt (45.6%), were from poor households (44.2%), were currently married (52.9%) and were employed (54.6%). Respondents from poor households had the highest internet usage rate (89.7%) compared to those from middle (72.8%) and rich (57.2%) households (p-value = 0.000). Detailed characteristics of the respondents can be seen in Table 1.

Prevalence of Internet use in the last 3 months

Figure 1, shows the prevalence of Internet use among respondents in the last 3 months before the census. Most respondents (75%) used the Internet 3 months before the census. The prevalence of Internet usage among reproductive-aged women in this study is higher than the prevalence reported in Northern Nigeria (4.3%) (Okunlola et al., 2023) and Ethiopia (about 5%) (Meshesha, 2023). Notably, Meshesha's (2023) and Okunlola et al.'s (2023) studies measured Internet use in the last 12 months. Also, both studies used the Demographic and Health Survey data. Despite the high prevalence of Internet use among women, there is a need to strengthen public campaigns to increase Internet use among women to enhance their access to healthcare information and services, education, and opportunities.

Table 1: Socio-demographic characteristics of respondents

Socio-demographic characteristics	Frequency (%)	Internet use		p-values
		Yes (%)	No (%)	
Age				
15-19	162,860 (20.1)	119,002 (73.1)	43,858 (26.9)	0.000
20-24	148,650 (18.3)	125,189 (84.2)	23,461 (15.8)	
25-29	134,227 (16.6)	109,901 (81.9)	24326 (18.1)	
30-34	121,041 (14.9)	91,443 (75.5)	29,598 (24.5)	
35-39	102,958 (12.7)	73,181 (71.1)	29,777 (28.9)	
40-44	79,047 (9.7)	50,738 (64.2)	28,309 (35.8)	
45-49	62,239 (7.7)	38,369 (61.6)	23,870 (38.4)	
Educational level				
No formal education	189,120 (23.3)	41,594 (22.0)	147,526 (78.0)	0.000
Pre-school/Primary	68,033 (8.4)	43,656 (64.2)	24,377 (35.8)	
Junior High School/Middle	249,544 (30.8)	226,948 (90.9)	22,596 (9.1)	
Senior High School and higher	304,325 (37.5)	295,625 (97.1)	8,700 (2.9)	
Religious affiliation				
Not religiously affiliated	21,485 (2.6)	11,827 (55.0)	9,658 (45.0)	0.000
Religiously affiliated	78,9537 (97.4)	595,996 (75.5)	193,541 (24.5)	
Marital status				
Currently married	428,747 (52.9)	297,657 (69.4)	131,090 (30.6)	0.000
Ever married	50,022 (6.2)	33,101 (66.2)	16,921 (33.8)	
Never married	332,253 (41.0)	277,065 (83.4)	55,188 (16.6)	
Place of residence				
Urban	493,243 (60.8)	417,000 (84.5)	76,243 (15.5)	0.000
Rural	317,779 (39.2)	190,823 (60.0)	126,956 (40.0)	
Ecological zone				
Northern belt	370,071 (45.6)	301,977 (81.6)	68,094 (18.4)	0.000
Middle belt	298,534 (36.8)	238,642 (79.9)	59,892 (20.1)	
Coastal belt	142,417 (17.6)	67,204 (47.2)	75,213 (52.8)	
Wealth index				
Poor	358,366 (44.2)	321,465 (89.7)	36,901 (10.3)	0.000
Middle	175,386 (21.6)	127,687 (72.8)	47,699 (27.2)	
Rich	277,270 (34.2)	158,671 (57.2)	118,599 (42.8)	
Employed status				
Unemployed	368,350 (45.4)	278,177 (75.5)	90,173 (24.5)	0.000
Employed	442,672 (54.6)	329,646 (74.5)	113,026 (25.5)	
Total	**811,022 (100.0)**			

Source: Field Data (2023)

Prevalence of Internet use in the last 3 months

As shown in Figure 1, most respondents (74.6%) used their mobile phone to access the Internet, followed by a laptop (6.8%) and television (3.6%) (Figure 2). The dominant use of mobile phones to access the Internet is unsurprising since studies have found high mobile phone ownership in Ghana (Ghana Statistical Service (GSS) & ICF, 2024; National Communication Authority (NCA) & Ghana Statistical Service (GSS), 2020).

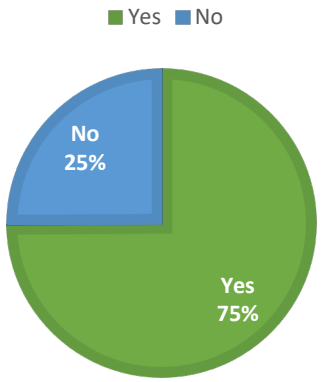

Figure 1: Prevalence of Internet use in the last 3 months

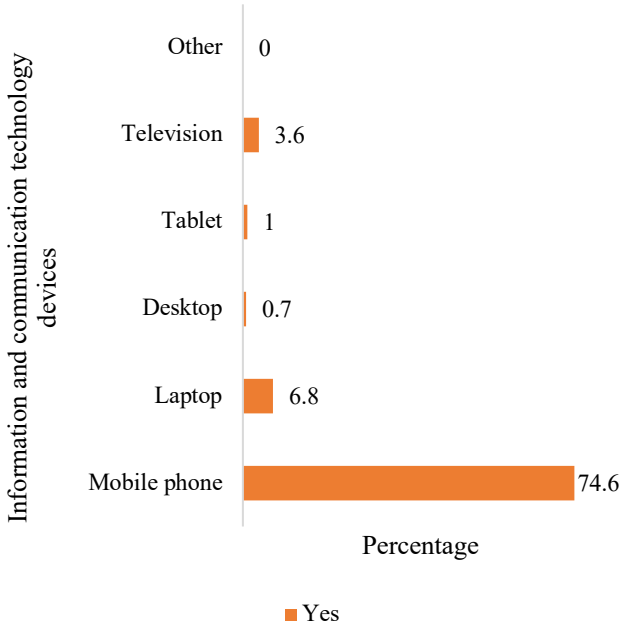

Figure 2: Information and communication technology devices used to access the Internet

Table 2, shows the socio-demographic determinants of Internet use among respondents. Compared to respondents aged 15-19, those aged 20-24 [aOR = 9.092; 95% CI = 8.802– 9.392], 25-29 [aOR = 9.864; 95% CI = 9.525– 10.214], 30-34 [aOR = 8.100; 95% CI = 7.812– 8.398], 35-39 [aOR = 7.132; 95% CI = 6.872– 7.402], 40-44 [aOR = 6.172; 95% CI = 5.937– 6.417], and 45-49 [aOR = 5.753; 95% CI = 5.525– 5.991] were more likely to use the Internet. However, the odds of Internet use declined with increasing age. A plausible explanation is that older women (44-49 years) may not be enthused about the Internet compared to younger women since Internet use may not have been an integral part of their upbringing. However, the findings of this study contradict Meshesha's (2023) study finding that

women aged 15-24 were more likely to use the Internet than women aged 25-34, and 35-49.

Regarding educational level, respondents with Senior High School and higher education were more likely to use the Internet than those with other educational categories. For instance, respondents with Junior High School/Middle [aOR = 0.413; 95% CI = 0.402–0.424] were less likely to use the Internet than those with Senior High School and higher education. This finding supports prior studies indicating a positive correlation between higher levels of education and Internet usage (Bergström, 2015; Dabalen & Mensah, 2023; Lera-López et al., 2011; Macur et al., 2016). Education enhances the adaptation of technology, including Internet use (Timotheou et al., 2023). There is a need to provide students with increased access to the Internet at both pre-tertiary and tertiary educational institutions to enhance their learning. This initiative will be beneficiary to both school-going males and females.

Respondents who were affiliated with a religion [aOR = 1.254; 95% CI = 1.204–1.305] were more likely to use the Internet than those who were not affiliated with a religion. Since the emergence of COVID-19, there has been increased participation in online religious activities (Kühle & Larsen, 2021; Parish, 2020), which could explain why women who are religiously affiliated were more likely to use the Internet than those who were not religiously affiliated.

Additionally, respondents who were currently [aOR = 1.225; 95% CI = 1.196–1.255] and ever married [aOR = 1.157; 95% CI = 1.115–1.200] were more likely to use the Internet than those who were never married. According to Al-Hammadany and Heshmati (2011), married women may need the Internet to access information and support for their health and that of their partner and children. This may explain why married women are more likely to use the Internet than those never married. It is worthy of note that the finding of this study contradicts Meshesha's (2023) study finding that never married women were more likely to use the Internet than married women.

In Ghana, Internet infrastructure and connectivity are better in urban areas than in rural areas (Baylon & Antwi-Boasiako, 2016). This may explain the study findings that respondents residing in rural areas were less likely to use the Internet than those living in urban areas. This finding supports prior studies, which found higher odds of Internet use in urban areas than in rural areas (Lera-López et al., 2011; Meshesha, 2023). There is a need for policymakers to provide incentives, such as tax holidays, to mobile telecommunication companies that expand and enhance their Internet connectivity in rural areas to improve Internet usage in those areas.

This study revealed that respondents in the Northern belt of Ghana were more likely to use the Internet than those in the Coastal belt [aOR = 0.636; 95% CI = 0.623–0.649]. This finding is surprising since previous studies have found higher Internet use in the Coastal belt than in the Northern belt (Dabalen & Mensah, 2023). However, respondents in the Middle belt [aOR = 1.046; 95% CI = 1.029–1.065] were more likely to use the Internet than those in the Northern belt, which confirms the findings of previous studies (Dabalen & Mensah, 2023). There is a need for further studies to use qualitative approaches to

explore the reasons for the differentials in Internet use in the Northern and Coastal belts.

Surprisingly, respondents from the middle [aOR = 0.682; 95% CI = 0.668–0.697] and rich [aOR = 0.531; 95% CI = 0.521–0.541] households were less likely to use the Internet than those from poor households. Studies have shown a positive association between the wealth index and Internet usage (Dabalen & Mensah, 2023; Matthews et al., 2019). This finding does not support Meshesha's (2023) finding that women from middle and rich households were more likely to use the Internet than those from poor households. Future studies are needed to explore why women from poor households are more likely to use the Internet than those from middle and rich households.

Furthermore, employed respondents [aOR = 1.489; 95% CI = 1.462–1.517] were more likely to use the Internet than unemployed respondents. This finding corroborates previous studies that found that Internet use was more prevalent among employed individuals than among unemployed individuals (Petrosyan, 2022). There is a need for future studies to explore why employed women are more likely to use the Internet than unemployed women since women from middle and rich households were less likely to use the Internet.

Strengths and limitations of the study

The main strengths of this study are the large sample size and that it covered all Ghanaian women aged 15-49. However, it has some limitations. First, the study was cross-sectional. Therefore, causality cannot be established. Second, this study did not explore factors hindering internet use among all women.

Table 2: Socio-demographic determinants of Internet use

	aOR	P-value	95% C.I. for aOR	
			Lower	Upper
Age				
15-19 (RC)				
20-24	9.092	0.000	8.802	9.392
25-29	9.864	0.000	9.525	10.214
30-34	8.100	0.000	7.812	8.398
35-39	7.132	0.000	6.872	7.402
40-44	6.172	0.000	5.937	6.417
45-49	5.753	0.000	5.525	5.991
Educational level				
No formal education	0.004	0.000	0.004	0.005
Pre-school/Primary	0.028	0.000	0.027	0.029
Junior High School/Middle	0.413	0.000	0.402	0.424
Senior High School and higher (RC)				
Religious affiliation				
Not religiously affiliated (RC)				
Religiously affiliated	1.254	0.000	1.204	1.305
Marital status				
Currently married	1.225	0.000	1.196	1.255
Ever married	1.157	0.000	1.115	1.200
Never married (RC)				
Place of residence				
Urban (RC)				
Rural	0.532	0.000	0.524	0.541
Ecological zone				
Northern belt (RC)				
Middle belt	1.046	0.000	1.029	1.065
Coastal belt	0.636	0.000	0.623	0.649
Wealth Index				
Poor (RC)				
Middle	0.682	0.000	0.668	0.697
Rich	0.531	0.000	0.521	0.541
Employment status				
Unemployed (RC)				
Employed	1.489	0.000	1.462	1.517

aOR = Adjusted Odds Ratio, RC = Reference
Category, C.I. = Confidence Interv

Conclusions

The prevalence of Internet use among women of reproductive age was high (75%). Mobile phones were the main ICT device women used to access the Internet. Also, women's age, educational level, religious affiliation, marital status, place of residence, ecological zone, wealth index, and employment status were significant determinants of Internet use. Policymakers should consider these factors when promoting Internet use among women of reproductive age.

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Land Use Competition and Changes in Ecosystem Services in Riparian Areas For 30 Years

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Abstract

This study examines land-use changes and ecosystem services in the Densu River Basin riparian zone over 30 years using LANDSAT imagery and ArcGIS10.8. The classification accuracy for 2021 was 86.14% with a Kappa coefficient of 0.854. Significant land-use changes were observed: from 1991 to 2002, forest/shrubland declined by 24.2% while arable crop land increased by 29%. From 2002 to 2021, forest/shrubland increased by 20% and arable crop land decreased by 26%. Built-up areas slightly increased by 1.2%. Interviews with 448 residents and Chi-Square analyses revealed significant decreases in food provisioning services, particularly downstream near the capital. The study recommends sustainable agriculture and urban forestry practices to conserve forest and water resources, along with tree planting initiatives to enhance ecosystem services.

Keywords: Land use competition, Land-use/land-cover, Riparian Forest, Ecosystem services, Satellite imagery, Densu River Basin

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Introduction

Riparian zones refer to parcels of land adjacent to water bodies (Naiman & Decamps, 1997). They are highly valuable natural resources on earth endowed with dynamic ecosystems that provide a greater portion of water for domestic, agricultural, commercial, and ecological needs of communities along the catchment (Calder et al., 2007). They are characterised by high species richness and are most diverse and productive in nature (Sunil et al., 2011). The vegetation and water bodies have several provisioning and regulatory functions that demonstrate carbon storage and sequestration, regulation of water flows, protection of the freshwater systems and resources. Furthermore, the forest serves as a water purification component and a source of bioenergy for human life and feed for animal species (Calder et al., 2007; Kankam et al., 2022; Inkoom & Fürst, 2022).

Riparian zones are considered endangered and potentially threatened ecosystems due to the abusive and intensive land use by man (Gopal, 1998; Natta et al., 2002; Sunil et al., 2011). The hydrological and geomorphic components of riparian forests are susceptible to natural and anthropogenic activities interacting at multiple spatial and temporal scales to influence the composition, ecological processes, and ecosystem functions of the catchment (Millennium Ecosystem Assessment [MEA], 2005; Milton and Finlayson, 2019). Owing to the high biodiversity scale of riparian forests and the accompanying provisioning functions, they are attractive to human life and provide several goods and services for human well-being (Singh et al., 2021). Consequently, riparian forests are threatened by human influence, and they are also susceptible to exotic species invasion (Sunil et al., 2011). Globally, the world's major river basins such as the Amazon Basin and the Mediterranean landscape have all experienced human disturbances and have lost their originality (Sunil et al., 2011).

The characteristics of riparian forests differ along the stretch of the catchment in microclimate, soil, vegetative structure, topography, moisture regimes, disturbance regimes and overall productivity. These differences in the various segments along the catchment tend to influence the extent of biodiversity and ecosystem services (Singh et al., 2021). Currently, riparian forests are experiencing threats due to the increasing human population and its associated urbanisation, agricultural activities, over-exploitation of mineral resources, and climate change that is both naturally and anthropogenically induced (Akurugu et al., 2022; Anim Ofosu et al., 2020). These threats not only result in changes in land-use and land-cover, affecting biodiversity and originality of riparian zones, but also in changes in the ecosystem services of the zone. Aggravated by climate change, the effect of these threats is likely to increase the vulnerability levels and worsen human livelihood (Pedrono et al., 2016).

Various studies on riparian areas show declining forest cover and competing use of forest land for other land-use purposes. Yorke and Margai (2007), using multi-temporal satellite images of 1990 and 2000 to monitor land-use change, noted a decline in forest land mainly due to an increase in residential land use. They also identified a conversion of farmland from tree crops to food crops during

the period. Attua et al., (2014) also evaluated the water quality variability and land-use/cover attributes using the Pearson's correlation and linear regression statistical techniques. They found water quality variability to be influenced by seasonality and geographical location. Also, spatial differences of water quality variability reflected local variability in land use, geology, lithology, and soil properties across the basin.

In addition, Adjei et al., (2019) also examined the trend in land-use and land-cover changes that occurred within the basin over 30 years by using Landsat Thematic Mapper (TM) images for the years 1986, 1991, 2002, 2013 and 2018. Their classification scheme was made up of Settlement and Bare land, Forest, Shrub and Grassland, Farmland and Water Bodies. Furthermore, Anim Ofosu et al., (2020) identified and mapped areas prone to ecological vulnerability within the Densu Basin using Geospatial Technology to develop a model by combining analytical hierarchical process (AHP) and multicriteria methods (MCM) with datasets of land-use/land-cover, soil types, slope, drainage density, rainfall variability and spatial distribution of the communities within the basin. The model was meant for flooding, drought, and surface water quality vulnerability. Their results revealed that about 15% of the basin was highly vulnerable to flooding, and 1% was prone to drought and 6% was prone to poor surface water quality. Akurugu et al., (2022), also noted a risk of diminishing rate of recharge of groundwater in the DRB due to climate change threats.

In other geographical settings such as China, there is evidence of a decrease in forest cover in the Anthropogenic era as compared to the Holocene. Ren (2007) used pollen map data at 2000-year intervals to reconstruct changes in forest cover north of the Yangtze River. Findings show that during the early Holocene from 10 ka B.P to 6 ka B.P. there was an increase in forest cover in almost all the regions studied. However, from 6 ka to the time of the study, forest cover decreased by 50%.

Despite the existing literature, associated changes in ecosystem services following changes in land use is not well investigated. More so, studies on the DRB have predominantly focused on the water resources only without a focus on the forest resources. Therefore, there is limited knowledge of land use changes and ecosystem services of riparian areas. Similar studies on ecosystem services have focused on only the water in riparian area such as the Volta River Basin (Agodzo, 2013), and the Niger Delta (Ayanlade and Proske, 2015), but not the entire water-vegetation-associated landscape.

Furthermore, studies also focused on only terrestrial landscapes such as the Ejisu Juaben Forest Dissected Plateau region of Ghana (Tutu Benefoh, 2008). In the era of climate change adaptability, the need for retrospective studies of competition in land use and the associated changes in ecosystem services cannot be overemphasized. This study examines the competing land uses among forest, agricultural, and settlement land use, and the associated changes in ecosystem services in a riparian setting from 1991 to 2022.

2.0 Materials and Methods

2.1 Study area

The study took place within the catchment of the Densu river in Ghana. The Densu river takes its source from the Atewa-Atwiredu mountains in the Eastern Region of Ghana and flows downstream to the Greater Accra Region. Geographically, the basin stretches from longitude 0° 10' 0" to 0° 35' 0" West and latitude 5° 30' 0" to 6° 15' 0" North of the equator. With an estimated drainage area of 2,490 km² and a length of 160 km, it meanders downwards into the Weija reservoir and flows finally into the Gulf of Guinea (Anim Ofosu et al., 2020; Gyima et al., 2020). The course of the river meanders through communities like Ntunkum, Atiebu and Anum Apapam (upstream) and Nsawam, Adoagyir and Amanfrom, midstream. It flows downstream through Weija, Tetegu, Mallam and Oshiyie before entering into the Weija reservoir and finally into the Gulf of Guinea (Figure 1). The DRB is located within the Eastern and Greater Accra regions. Currently, these two regions constitute 27.2% of the total population of Ghana. Greater Accra region constitutes the largest region (17.7%) of Ghana, and the Eastern region consitutes the third largest region after the Ashanti Region. With an increase in Ghana's population from 12,296,081 in 1984 to 30,832,019 in 2021, the population of these regions would have increased significantly. From the year 2000 to 2021, the rural population of the Greater Accra Region increased by 19.9%, as the urban population increased by 36.7%. For the Eastern Region, there was also an increase in the urban population by 31.6%. However, there was a decrease in the rural population by 4.7% (Ghana Statistical Service [GSS], 2021). The main economic activities along the DRB are fishing, farming, palm-wine tapping and artisanal services.

2.1.1 Stratification of the Study Area

To identify differences in land use along the stretch of the Densu River Basin, the study area was demarcated into three segments namely the upstream, midstream and downstream segments (Figure 1). The upstream and midstream segments fall within the semi-deciduous rainforest ecological zone while the downstream segment falls within the coastal savannah ecological zone. Studies have shown that the characteristics of riparian forests are not equal along the length of the river basin (Singh et al., 2021). Consequently, the need to stratify the study area is important. Furthermore, this stratification enhanced an effective analysis for policy guidance

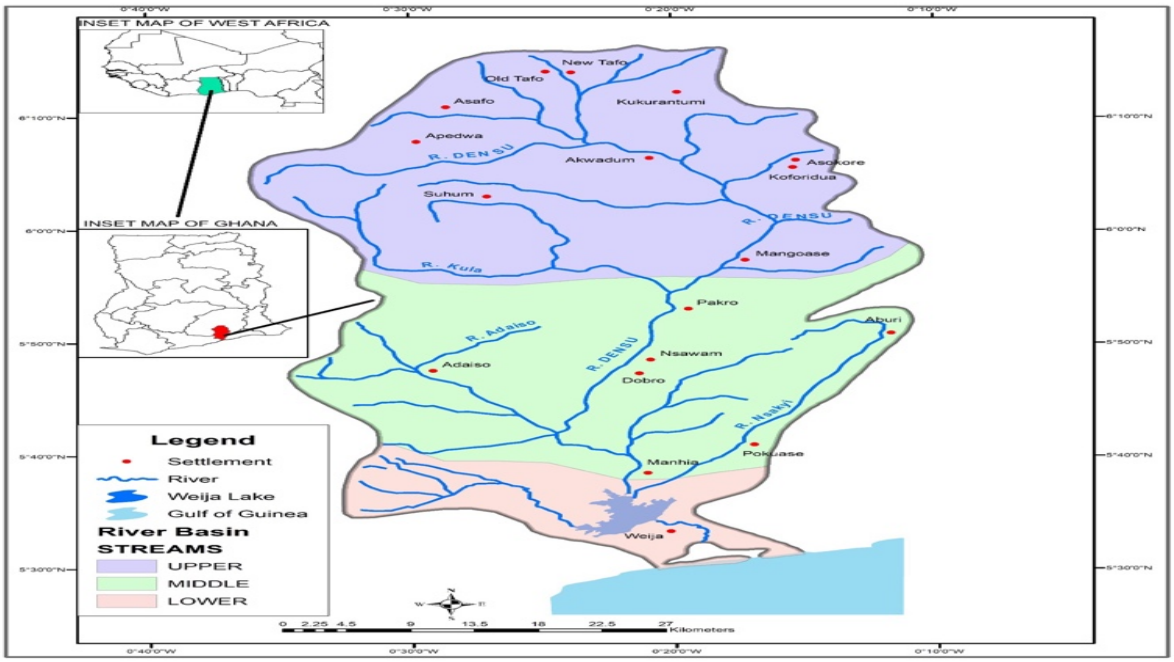

Figure 1: Map of the Densu River Basin with stratified study zones

Data

Satellite Data

Remote sensing technique is one of the modern tools used to monitor changes in land-use and land-cover over some time. This research made use of satellite imagery to analyse the land-use and land-cover changes over 30 years (1991, 2002, and 2021). The specific years were selected due to LANDSAT images availability and those with less than 20% cloud cover[1]. The satellite scenes chosen were acquired in the dry season to minimize the influence of seasonal variations and for effective comparison. Besides, ancillary data consisting of existing land-use and land-cover maps and Global Position Systems (GPS) points recorded from the field complemented the image processing. The Landsat imageries were downloaded from the United States Geological Survey (USGS) website (https://glovis.usgs.gov) with the characteristics indicated in Table 1. The images were downloaded in a compressed form and were extracted into a directory.

[1] The satellite data for 2022 could not be used as the study period was in the rainy season when the cloud cover was above 20%. Consequently, data for December 2021 was used.

Table: Satelite imagery characteristics

No	Landsat Type	Path/Row	Acquisition Date	Land cloud cover (%)
1	Landsat 8-9 OLI/TIRS C2 L1	193/056	22/12/2021	1.48
2	Landsat 7 ETM+ C2 L1	193/056	26/12/2002	0.00
3	Landsat 7 ETM+ C2 L1	193/056	17/01/1991	19.0

Source: https://glovis.usgs.gov

Survey Data

Population and Sampling

The communities within the DRB catchment constitute the study population. On that basis, 15 communities within the DRB were randomly selected for the study and a total number of 448 respondents were interviewed. Based on the variations in sizes and populations of the communities, the numbers chosen from each segment of the DRB varied. Six communities upstream were selected as four were selected from midstream and five from downstream. A total of 114, 183 and 149 respondents were respectively interviewed from the upstream, midstream and downstream segments. (Table 2).

Consequently, a two-stage sampling procedure was followed for the survey. The first stage involved a random sampling of a total of 15 communities within the DRB and the second stage involved a selective sampling of respondents who had lived in the communities for at least 30 years and were at least 42 years old at the time of interview and could also recall the ecological features of the study area 30 years ago.

Data Collection Procedure and Instrumentation

For the survey, a structured questionnaire was designed based on the objective of assessing changes in ecosystem services of the water and forest. The instrument was designed following the Common International Classification for Ecosystem Services (CICES V5.1). Data collected include the ecosystem services of the water and forest resources as at the time of data collection (2022) and some 30 years ago. Ecosystem services include food and cultural services. We focused on the divisions of biomass and water under the provisioning and cultural services (Haines-Young & Potschin, 2018).

Provisioning services of the riparian forest include food of all kinds, fuel wood, medicinal herbs and timber. Cultural services include the use of the forest for religious activities, tourism and entertainment and cultural heritage (MEA, 2005). For the water, food provisioning covered the provisioning of fish, crustaceans and all other edible animal sources from the river. We also included the uses of the water for crop irrigation, livestock watering and household domestic activities. The use of the water as a means of transportation and religious purposes were also considered.

Table 2: Sample communities and sizes

Segment	Communities selected	Number of respondents
Upstream	Akwadum Mangoase Abrodem Bibianiha Densuano Densuso	114
Mid-stream	Adaiso Nsawam Dobro Adoagyire	183
Downstream	Weija, Tyre Top, Tetegu, Pambros Oblogo	149
	Total	**446**

Source: Field Survey, 2022

We acknowledge the diversity in the definition of ecosystem services as illustrated by Braat and De Groot (2012) and include both goods and services that humans benefit directly and indirectly from the forest and water resources.

The nature of the study required a targeted set of respondents. Prior to the interview, the nature of the study and requirements were explained to each person and selection was made based on this. Due to ethical requirements, the interviewers avoided asking the ages of the interviewees in order to ascertain whether they qualify for the study. Data was collected through face-to-face interviews.

Data Analysis

Using ArcGIS 10.8, the images were loaded in turns according to bands and a composite was generated using bands 1 to 5 and 7. A vector shape file of the basin with the same coordinate projection (*DATUM - WGS84, ELLIPSOID, UTM ZONE – 30*) was superimposed and clipped as the study basin. Both unsupervised and supervised classifications were performed in ArcGIS 10.8. The former classification was performed first using the Iterative Self-Organizing Data Analysis (ISODATA) clustering algorithm, aimed at identifying areas with similar classes which would aid the latter classification. Prior to the supervised classification, a scheme was developed based on existing literature (Antwi,

et al., 2014; Ayivor & Gordon, 2012), expert knowledge, and field observation; thus, *i) Built-up /settlement/ bare surfaces, ii) Waterbody/salt flats, iii) Open-access Forest/shrubland and iv) Mixed arable crops & grass/herb fallow*. On that basis, training sites were identified and digitized after which the signature file was generated and conducted the classification using the Maximum Likelihood algorithm (ML) on ArcGIS 10.8 platform and land-use/land-cover maps were generated according to the periods (Figure 2). The maximum likelihood classification algorithm was chosen because it is not affected by the size of the training data sets as noted in the literature (Li et al., 2014 cited in Adjei et al., 2019). The history of trends and changes in land-use/land-cover was obtained from the chiefs, opinion leaders and heads of households during the ground truthing.

For the survey data, Chi-Square analyses were made using STATA version 15, to assess the changes in ecosystem services between 1991 and 2022. Chi-Square analyses proves if the changes in ecosystem services for 1991 and 2022 are significantly different from zero. The analysis of changes in ecosystem services was guided by the Common International Classification for Ecosystem Services (CICES V5.1).

Accuracy Assessment

An accuracy assessment is a crucial operation performed to evaluate both land use and land cover category, and general errors emanating from the classified imagery and evaluate the reliability of the map generated. For the study, such an assessment was carried out on the 2021 classified image, because of the availability of ground truth as of 2022. For the 2002 and 1991 images, ground-truth data were unavailable, but the same classification methodology was used for both images. For the 2021 classified image, 50 pixels of each land use and land cover category were randomly selected (a total of 200 pixels) and checked for accuracy using ground-truth data complemented with Google Maps. A total of 12 cases were discarded because those points were unclear from the visual inspection of the imagery as to the land use and land cover categories. The standard summaries were reported for the accuracy assessment: the error matrix, which quantitatively compares the relationship between the classified map and the reference data, the overall accuracy, and the Kappa coefficient (Cohen, 1960; Congalton, 1991). The overall accuracy for the 2021 classified image based on supervised classification was 86.14% which is above the United States Geological Survey (USGS) guideline of 85% therefore the classification was considered good. Besides, the Kappa coefficient was 0.854, which means that 85.4% of the classification was better than a random classification. The results can be described as good because a Kappa value above 80% is considered to have a strong agreement (Rosenfield & Fitzpatrick-Lins, 1986).

Results

Demographic characteristics of respondents

Table 3 presents the demographic characteristics of the respondents. Males constituted approximately 55% of the sample while females were 45% of the sample. A majority of the respondents were in the age bracket of 40-49 years and many (37%) were engaged in trading activities. Those in artisanal activities are 14.8% and an equal

number are not employed. Respondents in farming activities were 14.1% of the sample.

Land-use land-cover changes (1991 to 2021)

The derived land-use and land-cover for the DRB for the years 1991, 2002, and 2021 are shown in Figure 2. The statistics generated by the various land-use/land-cover categories are equally shown in Figure 3 and Table 4. The results of the image analysis indicate that in 1991, areas classified as open-access forest/shrubland was 41%, mixed arable crops and grass/herb fallow was 34.5% and built-up/settlement/bare surfaces was 23.4%. (Figure 3; Table 4). A different situation emerged in 2021. Areas classified as open-access forest decreased to 36.9%. This registered a decrease of 4.1% (Table 4). Mixed arable crops and grass/herb fallow land use

Table 3: Demographic Statistics of the Respondents

Demography	Percentage (%)	Number
Location		
Upstream	25.6	114
Midstream	41.0	183
Downstream	33.4	149
Sex		
Male	54.6	243
Female	45.4	202
Age		
40-49 years	52.4	233
50-59 years	22.5	100
60-69 years	23.4	104
>69 years	1.8	8
Occupation		
Not employed	14.8	66
Trading	36.8	164
Farming	14.1	63
Artisanal	14.8	66
White-coloured	16.1	72
Others (Fishing, fishmongering, hunting)	3.4	15

Table 3: Demographic Statistics of Respondents (cont'd)

Demography	Percentage (%)	Number
Marital Status		
Married	50.5	225
Single	26.7	119
Widowed	7.4	33
Divorced/Separated	15.3	68
Household Size		
1-5	44.7	199
6-10	40.9	181
11-15	9.3	41
16-20	3.8	17
21+	1.1	5
Education		
No formal education	18.8	84
Pre-School	10.3	46
Primary education	12.6	56
JHS/JSS	11.9	53
Middle School	17.5	78
SSS/SHS/Vocational	15.0	67
Tertiary	13.9	62
Number of years of living in the community		
30-34 years	29.9	133
35-39 years	28.1	125
40-44 years	17.1	76
45-49 years	11.7	52
50-45 years	8.5	38
55 years and above	4.7	21

Source: Field Survey, 2022

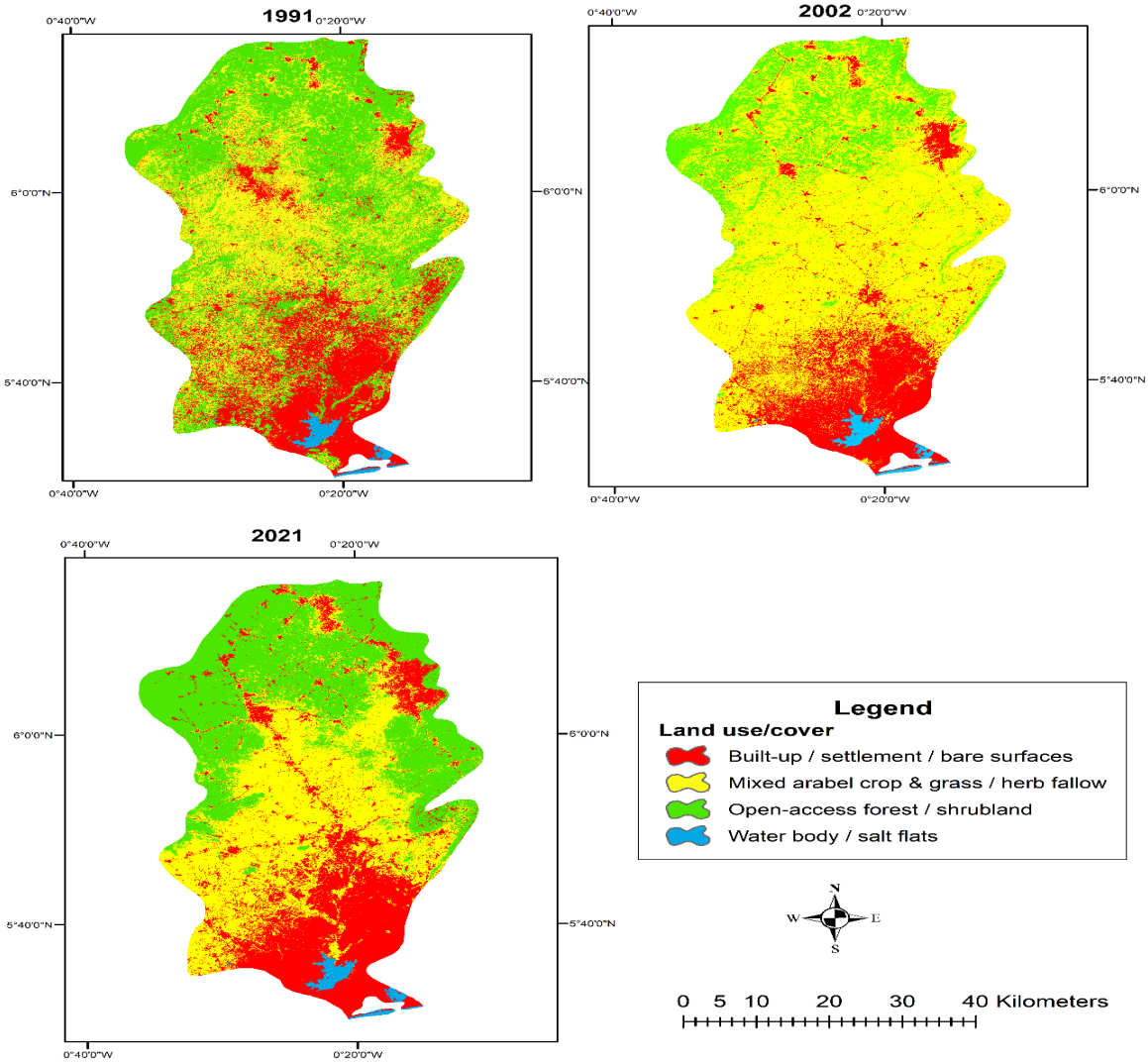

Figure 2: LULC change from 1991 – 2002 and 2002 - 2021

Land-use land-cover changes (1991 to 2021)

The derived land-use and land-cover for the DRB for the years 1991, 2002, and 2021 are shown in Figure 2. The statistics generated by the various land-use/land-cover categories are equally shown in Figure 3 and Table 4. The results of the image analysis indicate that in 1991, areas classified as open-access forest/shrubland was 41%, mixed arable crops and grass/herb fallow was 34.5% and built-up/settlement/bare surfaces were 23.4%. (Figure 3; Table 4). A different situation emerged in 2021. Areas classified as open-access forest decreased to 36.9%. This registered a decrease of 4.1% (Table 4). Mixed arable crops and grass/herb fallow land use increased from 34.5% in 1991 to 37.3% in 2021, an increase of 2.8% (Table 4). Built-up/settlement/bare surfaces also increased slightly by 1.2% (Table 4).

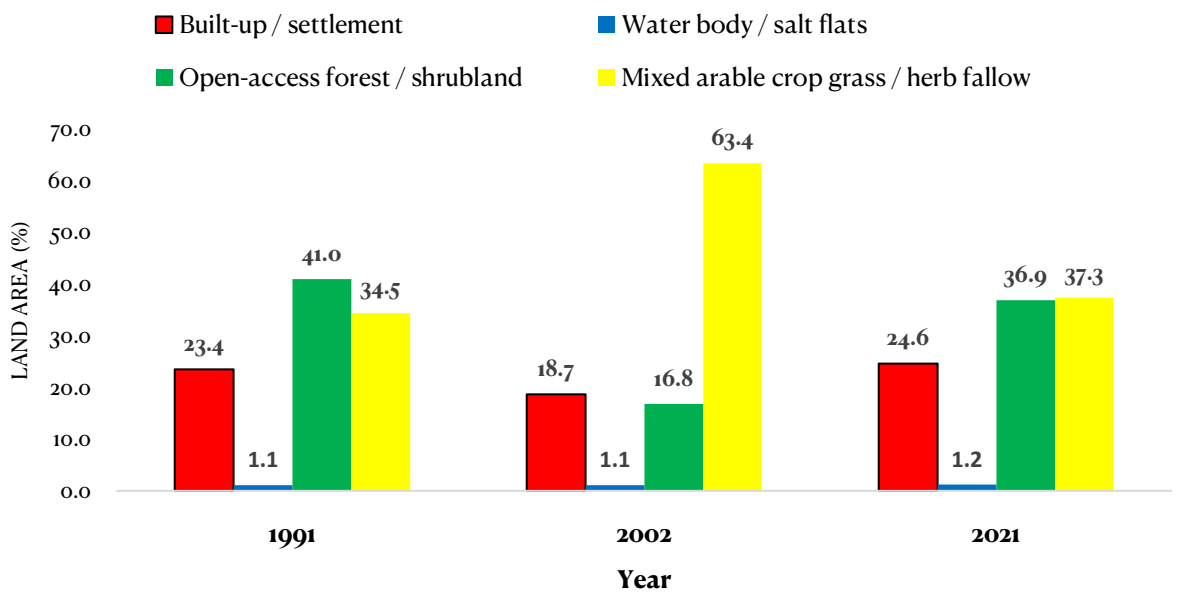

Figure 3: Land-use/land-cover categories in 1991, 2002 and 2021

Between 1991 and 2002, the land-use/land-cover changes were different for the land-use/land=cover types. Open-access Forest decreased by 24.2%, while mixed arable crops and grass/herb fallow land increased by 28.9%. Built-up/settlement/bare surfaces decreased by 4.7% (Table 4). This suggests that from 1991 to 2002, a loss of 24.2% of open-access forest to other land-use/land-cover types and a gain of 28.9 % of mixed arable crops and grass/herb fallow land from other land-use/land-cover types. There were no significant changes to the water body/salt flats. In 2021, open-access forest/shrubland and mixed arable crops and grass/herb fallow occupied almost the same amount of land area, 36.9% and 37.3% respectively while built-up/settlement/bare surfaces recorded 24.6% of the total land use of the basin (Figure 3 and Table 6).

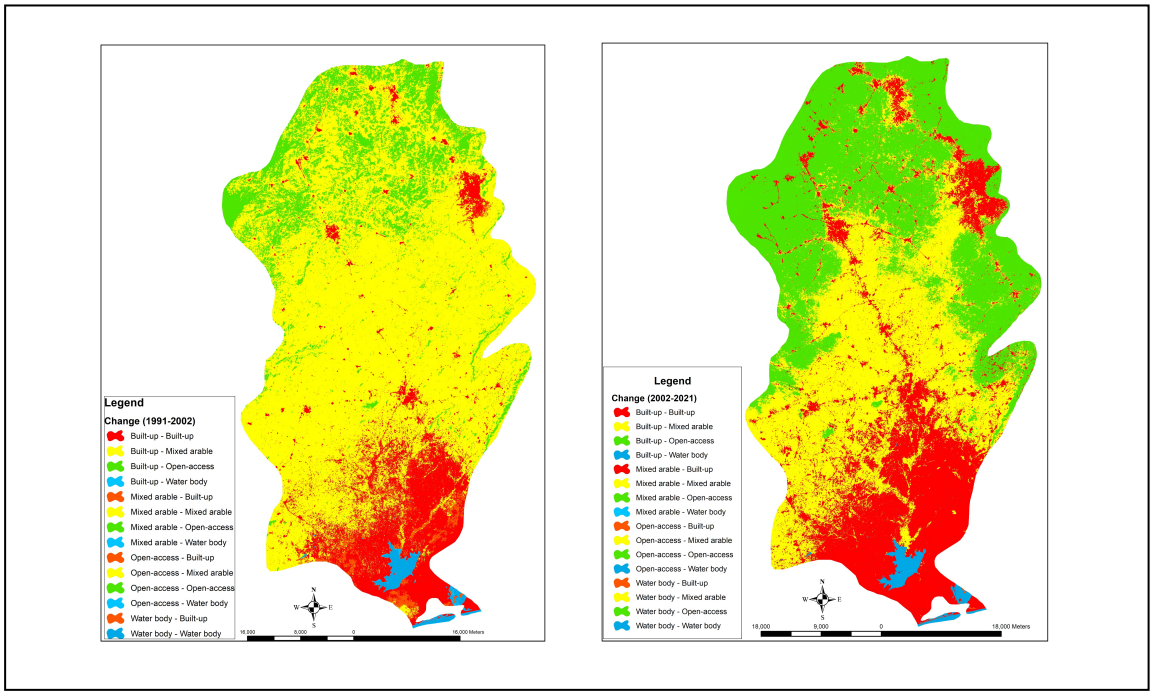

Figure 4: Percentage of area covered by LULC categories in 1991, 2002 and 2021

Land-use land-cover changes by image analysis (1991 to 2002) and (2002 to 2021)

The derived land-use and land-cover showing changes from 1991 to 2002 and 2002 to 2021 are shown in Figure 4. In terms of the magnitudes of the changes, between 1991 and 2002, open-access forest/shrubland lost 703.8 km² of land area to other land uses, mainly to mixed arable crops and grass/herb fallow (640km²). Built-up/settlement /bare surfaces lost 257.9 km² to other land uses while mixed arable crops and grass/herb fallow lost 69.5 km² to forest land use (69.5 km²) and 62 km² to settlements (Table 5). From 2002 to 2021, mixed arable crops and grass/herb fallow land use type lost 798.4 km² to other land use types (Table 6). Interestingly, a larger portion (572km²) was lost to open-access forest/shrubland. This was followed by built-up/settlement which lost 82.4 km² to other land uses, and open-access forest/shrubland also lost a total of 51 km² to other land use types, much of which (42km²) was lost to mixed arable crops and/grass/herb fallow land.

Table 5: Land-use/land-cover loss over 11 years

Land-use/land-cover change from 1991 to 2002			
From	**To**	**Km²**	**Net lost area (km²)**
Built-up/settlement/bare surfaces	Water body/salt flats	1.9	
Built-up /settlement/bare surfaces	Open-access Forest/shrubland	8.1	257.9
Built-up /settlement/bare surfaces	Mixed arable crops and grass/herb fallow	247.9	
Water body/salt flats	Built-up/settlement/bare surfaces	1.9	1.9
Open-access Forest/shrubland	Built-up/settlement/bare surfaces	63.0	
Open-access Forest/shrubland	Water body/salt flats	0.6	703.8
Open-access Forest/shrubland	Mixed arable crops and grass/herb fallow	640.2	
Mixed arable crops and grass/herb fallow	Water body/salt flats	0.0	131.5
Mixed arable crops and grass/herb fallow	Open-access Forest/shrubland	62.0	

Source: Field Survey, 2022

Table 6: Land-use/land-cover loss over 19 years

Land-use/land-cover change from 2002 to 2021			
From	**To**	**Km²**	**Net lost area (km²)**
Built-up /settlement/bare surfaces	Water body/salt flats	2.9	
Built-up /settlement/bare surfaces	Open-access Forest/shrubland	4.9	82.4
Built-up /settlement/bare surfaces	Mixed arable crops and grass/herb fallow	74.6	
Water body/salt flats	Open-access Forest/shrubland	0	1.1
Water body/salt flats	Mixed arable crops and grass/herb fallow	0.0	
Open-access Forest/shrubland	Water body/salt flats	0.0	51.0
Open-access Forest/shrubland	Mixed arable crops and grass/herb fallow	42.2	
Mixed arable crops and grass/herb fallow	Water body/salt flats	0.1	798.4
Mixed arable crops and grass/herb fallow	Open-access Forest/shrubland	571.6	

Source: Field Survey, 2022

Table 7: Ecosystem services of the riparian forest by location

Ecosystem Services	Upstream			Midstream			Downstream		
	1991	2022	p-value	1991	2022	p-value	1991	2022	p-value
Food	25.50	24.16	0.642	15.9	4.25	0.000***	8.05	4.03	0.011***
Timber	25.28	23.27	0.482	4.03	3.58	0.727	0.45	0.45	1.000
Fuel wood	25.50	25.28	0.939	40.72	38.93	0.585	28.64	23.71	0.094*
Medicinal herbs	25.50	23.04	0.391	40.49	38.93	0.632	32.89	27.96	0.109*
Cultural services	3.80	3.58	0.860	2.24	0.89	0.106	6.71	3.36	0.022**

Source: Field Survey, 2022

3.2 Changes in Ecosystem services (1991 to 2022)

3.2.1 Changes in Ecosystem services of the Riparian Forest Ecosystem services varied by location along the river basin. In the upstream segment, results show significant changes in all the dimensions of ecosystem services assessed except in timber provisioning. In the midstream segment, the only significant change was observed in food provisioning (p=0.011).

Changes in Ecosystem services of the water

The results from the study indicate some decreases in food provisioning in all the segments of the study area (Table 8). In the midstream segment, food provisioning functions of the water decreased significantly by 86.6% (p=0.000). There were significant changes in the use of the water for transportation functions in all the segments and changes in the use of the water for transportation services in all the segments. In the upstream segment, there was a decrease by 87.7% (p= 0.019). In the midstream and downstream segments, there were increases in the use of the water for transportation functions. None of the respondents indicated that in 1991, the water was used predominantly for transportation. However, 1.34% of respondents indicated that at the midstream and downstream segments, the water was used predominantly for transportation purposes.

there were no significant changes in any of the dimensions of ecosystem services assessed, namely provisioning of food, timber, fuel wood, medicinal herbs and cultural services (Table 7). However, in the downstream segments, the

Table 8: Ecosystem services of the water by location

Ecosystem Services	Upstream			Midstream			Downstream		
	1991%	2022%	p-value	1991%	2022%	p-value	1991%	2022%	p-value
Food	14.32	12.53	0.43	38.48	5.15	0.000***	33.11	32.44	0.83
Crop Irrigation	24.83	22.15	0.34	38.26	39.6	0.681	31.32	31.32	1.00
Livestock watering	25.06	25.28	0.94	26.40	30.65	0.16	23.71	26.40	0.35
Domestic use	25.28	25.28	1.00	39.60	40.04	0.89	31.99	30.65	0.66
Transportation	1.79	0.22	0.019***	0.00	1.34	0.014***	0.00	1.34	0.014***
Cultural/Religious use	10.74	12.08	0.528	4.03	4.92	0.518	31.32	31.77	0.885

Source: Field Survey, 2022

Discussion

Land-use land-cover changes

The changes in land use were not steady throughout the study period. From 1991 to 2021, areas classified as open-access forest decreased by 4.1%, while mixed arable crops and grass/herb fallow land-use land-cover type increased by 2.8%. Built-up/settlement/bare surfaces also increased slightly by 1.2% (Figure 3; Table 4). Comparing 1991 and 2002, there was a greater decrease of 24.2% in open-access forest and a greater increase of 28.9% in mixed arable crops and grass/herb fallow land-use land-cover type. Built-up/settlement/bare surfaces decreased by 4.7% (Table 4). Certainly, as shown by this study, mixed arable crops and grass/herb fallow took over much of the open-access forest land and some of the bare surfaces (Tables 5 and 6). From 2002 to 2021, there was a gain in open-access forest by 20.1% and a loss of mixed arable crops and grass/herb fallow land by 26.1% as built-up/settlement/bare surfaces increased by 5.9%.

Interestingly, this study identifies a loss of forest/shrubland to mixed arable crops and grass/herb fallow land and vice over time. Between 1991 and 2002, open-access forest/shrubland lost 703.8 km^2 of land area to other land uses and much of this loss (640.2 km^2) was to mixed arable crops and grass/herb fallow LULC type (Table 5). This suggests an increase in agricultural activities during this period. Similarly, built-up/settlement/bare surfaces also lost a total

of 257.9km² to other LULC types, of which 247.9 km² was lost to mixed arable crops and grass/herb fallow LULC type. It follows that as population sizes increases, the demand for food increases and land use is adjusted to meet food security needs. Overall, there has been strong competition in land use between open-access forest land use and agricultural land use. Periods that recorded a decrease in open-access forest land use also recorded an increase in agricultural land use and vice versa.

Our findings for the period 1991 to 2002 highlight the findings of Yorke and Margai (2007), who observed a conversion of agricultural land use from tree crop production to food crop production in the DRB from 1990 to 2000. This accounted for the increase in mixed arable crop and grass/herb fallow land cover type in this study. As population sizes increase, the demand for food increases and the need for food crop production increases. Tutu Benefoh (2008), also noted a loss of forest cover by 37% and an increase in grass cover by 62% between 1986 and 2007 in the Ejisu-Juaben District of Ghana,

Similar studies in other parts of Ghana also report different findings. Kusimi (2008), report a loss of forest cover and an increase in land use activities such as settlements, farms and mining. Here, land use competition is between forest land use and settlements. Again, in this situation, land use competition is between forest land use and grass cover. Another study which examined the LUCs of all the ecological regions of Ghana, also observed a decline in forest cover of both closed and open forests with an accompanying increase in built-up areas/settlements in all ecological regions of Ghana (Antwi et al., 2014). Consequently, the findings from this study are consistent with the findings on the decrease in forest cover.

The loss of land cover to mixed arable crops and grass/herb fallow suggests a proliferation of agricultural activity from 1991 to 2002. This can be attributed to the expansion of the Ghanaian economy during the Structural Adjustment Program era to accommodate the export of agricultural produce. The Structural Adjustment Programs implemented in Ghana from the mid to late 1980s resulted in trade liberalisation of the agricultural sector. This resulted in the opening of the export market and farmers started cultivating horticultural crops such as papaya, pineapple, mangoes and citrus for export for higher gains. At the same time, there was a reduction in rural-urban wage differentials and this resulted in a substantial migration of labour back into agriculture (Braimoh, 2009). Consequently, many Ghanaians engaged in farming as source of livelihood. In addition, a fruit processing company, Blue Skies, was established in 1998 at Doboro, a town in the mid-stream segment of the study area, which operates an out-grower scheme whereby farmers supply various horticultural crops such as mango, citrus, passion fruit, pineapple and papaya for processing mainly for the export market. Consequently, many farmers in the study area shifted to these crops (Yaro et al. 2017). These factors contributed to the attractiveness of agricultural activity in the study area and the resultant increase in mixed arable and agricultural land use.

From 2002 to 2021, the proportion of open-access forest/shrubland lost to mixed arable crops and grass/herb fallow land was 42.2 km². On the other hand, 576 km² of mixed arable land was lost to forest/shrubland (Table 6). This suggests an intensification of forest conservation activities from 2002 to 2021. It is likely agricultural land use was converted from the cultivation of food crops to tree crops during this period and fallowing of land. This finding resonates with the study of Wiafe and Asamoah (2018) who assessed LULC changes from 2002 to 2010 and observed the cultivation of forest tree species and fallowing of land that suffered illegal logging and bush fires.

Surprisingly, between 2002 and 2021, 226.7km2 of mixed arable crop land was lost to built-up areas/settlements or bare surfaces while the portion lost to open-access forest/shrubland was 571.6km2 (Table 6). These results suggest a growth in forest/shrubland LULC during this period. Our results indicate an increase in open-access forest by 20.1% from 2002 to 2021 (Table 4). Afforestation programs and the shift in production to tree crops could contribute to this development. Following the Structural Adjustment Programs in Ghana, some State-owned industries were privatised and the new owners introduced incentives to motivate farmers to provide the needed raw materials. Palm oil processing by private companies became a reality in the study jurisdiction and many farmers engaged in oil palm cultivation. Also, certain industries that depended on raw materials from tree crops, such as the Ghana Oil Palm Development Corporation, located in the Eastern Region were privatized. The private owners introduced and a new outgrower scheme where farmers had assurance of receiving payment for their produce. Consequently smallholder farmers shifted from food crop production to tree crop production such as oil palm in the late 1990s which matured as at 2021 to be captured as open-access forest (Huddleston & Tonts, 2007). In addition, the attractiveness of oil palm as an export-driven crop enhanced government's effort to promote agroforestry using oil palm as tree species (Kaysara et al., 2020). These myriad of factors have contributed to the increase in forest cover as at 2021. Despite these interventions, there was an overall loss in forest cover. This implies that the loss in forest cover would have been worse in the absence of these innovations, considering the increase in population size and the associated increase in settlements.

Changes in ecosystem services (1991 to 2022)

Changes in ecosystem services of the riparian forest (1991 to 2022)

At the upstream segment, there were no significant changes in any of the ecosystem services understudy. The midstream segment experienced changes in only food provisioning functions while the downstream segment experienced changes in almost all the dimensions of the ecosystem services understudy (Table 7). The results suggest a maintenance of the vegetative ecosystem at the upstream segments of the DRB, as there were no significant changes in ecosystem services. Forest conservation and agroforestry efforts do not only succeed in maintaining forest ecosystems but also contribute to food security by maintaining access to food crops, game animals, snails,

mushrooms and medicinal plants. In Ethiopia, a study reports on the benefits of fuel wood from the cultivation of agroforestry tree species *Acacia decurrens* on farmlands (Berihun et al. 2019).

The results suggest a significant decline in food provisioning services at the mid-stream segment (Table 7). Wiafe and Asamoah (2018) also identified a decline in provisioning services of the Ejisu-Juaben district in Ghana, following a decline in forest cover by 74% from 2002 to 2010. Another study in the Ejisu-Juaben District also found an average loss of 785.5 Gg of Carbon between 1986 and 2007 due to a decrease in forest cover by 37%. This is also associated with a reduction in carbon sequestration by 1,183 Gg. A study of land use scenarios and ecosystem services in two agricultural communities in Northern Ghana reports of greater food provisioning functions for legume-monocropping land use type in one community, while in another community, cereal-monocropping rather has a potential offer of greater provisioning functions (Koo et al. 2018). This highlights the relevance of user perception and values in attributing value to ecosystem functions.

The downstream segment experienced many changes in ecosystem services. There was significant decline in food provisioning, fuel wood, medicinal herbs and cultural services. The usefulness of the forest in timber production remained the same over the years. The downstream segment is in the Greater Accra Region, the capital City of Ghana, where the population growth rate is the highest as compared to all other regions (GSS, 2021). Consequently, the use of forest services is very intense currently.

There is evidence of variation in changes in ecosystem services along the various segments of the riparian forest. While there were little changes upstream, few changes were observed midstream, and many changes occurred downstream. This observation provides credence to the assertion that characteristics of riparian zones are not equal along the length of river basins (Singh et al,. 2021; Pettit & Naiman, 2007).

Changes in Ecosystem services of the Water (1991 to 2022)

Food provisioning functions of the water decreased significantly (p=0.000) midstream while the upstream and downstream segments did not record any significant changes. This finding depicts a decrease in water food resources such as fish, crabs, clams and other aquatic species in the midstream segment. The use of the water for transportation purposes varied significantly across all segments. Upstream, there was a significant decline (p=0.019) in the use of the water for transportation uses while midstream and downstream, showed decline in the use of the water for transportation uses (Table 8). The use of water for livestock watering also increased midstream and downstream by 16% and 11% respectively, but these changes did not show any statistical significance. However, this suggests an increase in livestock activities. Studies have shown a decline in fish species richness in the downstream segment of the Densu River Basin following the construction of a dam in the early 1980s, causing changes in the water conditions from a riverine state to a lacustrine condition. The disappearance of certain fish species such as *Hepsetus odoe, Heterotis*

niloticus and Brycinus nurse has been observed (Quarcoopome & Amevenku, 2010).

A strong competing land use between natural forest land use and agricultural land use was observed. From 1991 to 2002, open-access forest/shrubland declined by 24.2%, and mixed arable crop and grass/herb fallow land use increased by 29%. From 2002 to 2021, open-access forest/shrubland land use increased by 20%, while mixed arable crops and grass/herb fallow land-use decreased by 26%. A slight increase in built-up/settlements/bare surfaces by 1.2% over the entire period of study was also found.

Conclusion and Policy Implication

The paper sought to examine the changes in land-use/land-cover in the DRB and the associated changes in ecosystem services from 1991 to 2022. Unlike other studies on land-use/land-cover and ecosystem services changes, this study combined geospatial data with survey data. Geospatial data was used to examine the land-use land-cover changes while survey data was employed in studying the changes in ecosystem services of the forest and water. Our results generally show competing land use between open-access forest and mixed arable crop land for the period understudy. In years where forest land cover decreased, there was an increase in agricultural land use and vice versa. Interestingly, there is little land use competition between forest land use and settlements. From 1991 to 2002, open-access forest/shrubland declined by 24.2%, and mixed arable crop and grass/herb fallow land use increased by 29%. %. From 2002 to 2021, open-access forest/shrubland land use increased by 20%, while mixed arable crops and grass/herb fallow land-use decreased by 26%. Overall, from 1991 to 2022, open-access forest/shrubland decreased by 4.1 % while mixed arable crop land increased by 2.8% and built-up/settlement/bare surfaces increased by 1.2%. In addition, we noticed that over 85% of the decrease in open-access forest/shrubland was lost to mixed arable crop land while the remaining 15% was lost to built-up /settlement/bare surfaces. With increasing population sizes in riparian zones as a result of the availability of water, there is a likelihood of a high demand for food and the potential of losing forest/shrublands to agricultural activities. While the need for food security is eminent, we recommend sustainable agricultural practices that limit the use of land such as vertical farming to mitigate deforestation. In addition, conservation initiatives to demarcate some segments of the riparian forest as closed is timely. With increasing urbanization, there is also a likely pressure of land acquisition for settlements and other commercial activities, and a threat to open-access forest/shrubland is possible. Urban forestry practices and enforcement of tree planting initiatives by households and organized groups are highly recommended as conservation initiatives.

The study also examines the changes in the provisioning and cultural services of the riparian forest and water based on the classification of ecosystem services by Haines-Young and Potschin (2018). The results suggest a decrease in ecosystem services in the dimensions of food provisioning, fuel wood supply, medicinal herbs and cultural services. A detailed analysis shows a greater decrease in ecosystem services downstream, located in the Greater Accra Region, where

the population density is high. Increase in population sizes tends to impact negatively on the functions of forest ecosystems and this has an implication for food insecurity. While food provisioning functions of forest and water ecosystems are necessary for the survival of man, it is possible that the dependency of man will be overstretched and limit the availability of ecosystem resources over time. Efforts to conserve forest resources as human populations increase are necessary. Meanwhile, policies and education on forest conservation in riparian zones is recommended.

Similarly, the ecosystem services of the water were also assessed. Food provisioning e.g., fish, crabs, clams etc. decreased by 42% while the use of the water for livestock increased by 9%. A closer observation shows a significant decrease in food provisioning functions at the midstream segment but not at the upstream and downstream segments. This also has an implication for food security in the future, as the population increases. Sustainable fishing practices are recommended in the midstream segment.

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Forest Management Practices towards Biodiversity Conservation: Insights from Bobiri Forest and Butterfly Sanctuary in Ghana

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Abstract

Biodiversity conservation is critical due to global losses driven by illegal mining, population growth, harmful agriculture, and deforestation, necessitating interventions like afforestation and ecotourism. This study aimed to address the slow application of geographic tools in understanding the impact of human activities on biodiversity by using remote sensing and GIS. Landsat TM5 and ETM+ images from 1986, 2012, and 2020 were processed and classified into forest, grassland, farmland, and built-up areas. The analysis revealed an increase in forest cover from 1986 to 2012, followed by a decline from 2012 to 2020, with classification accuracies of 76% for 1986 and 72% for both 2012 and 2020. These findings underscore the need for enhanced conservation efforts. The study recommends policies and strategies to boost plantation programs and ecotourism initiatives to restore and maintain ecosystems.

Keywords: Remote sensing, GIS, ecosystem restoration, plantation programs, ecotourism

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1.0 Introduction

Conserving biodiversity has become a global challenge (Luque et al., 2018) and requires great attention. Biodiversity in all its forms is important for the provision of food, maintaining healthy ecosystems, and supporting the continuous survival of all species yet it has been threatened globally (Eshun et al., 2022). Biodiversity is crucial for its ability to provide important pharmaceutical products and nearly 80% of residents in developing countries depend on biodiversity for their healthcare support (Asiamah et al., 2020). All forms of biodiversity are very important because they help in building ecosystem resilience and keep various life forms within their tolerance level (Gatti et al., 2017). Human interactions with their ecosystems can enhance or degrade biodiversity in all its forms. It has been emphasized that biodiversity loss can be attributed to anthropogenic activities (Anwar et al., 2021; Arora, 2018; Jahan et al., 2021; Luque et al., 2018). Timber extraction is said to be one of the major factors causing species extinction in terrestrial ecosystems (Gatti et al., 2017) whereas other scholars feel that turning natural areas into a built environment has also contributed to biodiversity loss (Anwar et al., 2021). Samal & Gedam (2021) assert that land use and land cover keep changing because of natural and anthropogenic activities and these effects are worsened due to urbanization. The increase in population has resulted in pressure on forest resources and their conversion to other land-use types (Baidoo et al., 2023) which requires critical attention.

People depend on their environment to survive and their activities can have negative and positive implications on biodiversity. Positive activities including the delineation of protected areas and plantation programs can conserve biodiversity. There are 21 Protected Areas (PAs) in Ghana which include seven (7) national parks, six (6) resource reserves, two (2) sanctuaries, one (1) strict nature reserve, and five (5) coastal wetlands (Attuquayefio & Fobil, 2005; Damnyag et al., 2013). The coverage of PAs is threatened due to deforestation in and around forest areas that emanate from poaching, wildfire, farming, and grazing (Damnyag et al., 2013). There are also other activities such as mining, unplanned agriculture, and the development of built areas which can negatively affect biodiversity conservation. An increase in population has accelerated the rate of biodiversity loss as more natural areas are converted to meet the needs of the growing population (Anwar et al., 2021). Environmental education projecting the importance of biodiversity conservation is essential in changing attitudes and behaviour of people towards the environment, yet such actions have been slow (Eshun et al., 2022).

To tackle biodiversity loss, there is a need for strategies to enhance biodiversity conservation. Strategies such as plantation programs can help restore degraded areas. Positive agricultural practices can also improve agro-biodiversity. Luque et al. (2018) assert that there is a need to assess biodiversity distribution to inform planning on conservation issues and assess support for ecosystem services. Satellite images can provide information on degraded areas to inform policies and strategies for better conservation practices. Remote sensing applications can be used to study biodiversity

conservation in terrestrial and aquatic ecosystems (Geller et al., 2017; Jahan et al., 2021; Luque et al., 2018). They are also helpful in determining the spatial distribution of above-ground biomass (Forkuor et al., 2020). This can detect future risks associated with the loss of biodiversity and put in place measures to reduce such losses (Jetz et al., 2019; Luque et al., 2018). However, the application of innovative tools such as remote sensing and Geographic Information Systems (GIS) to analyze the effects of human actions on biodiversity has been slow. Even though studies have been conducted using remote sensing and GIS in Ghana, the majority have concentrated on urban land use (Acheampong et al., 2018; Biney & Boakye, 2021). As there exist gaps in the application of RS/GIS in studying forest reserves, particularly ecotourism destinations, (Baffour-Ata et al., 2021) have employed RS/GIS in studying the Bobiri Forest Reserve and Butterfly Sanctuary (BFRBS), however, they looked at both the built-up and the forest area. This research employs RS/GIS to analyze the land use land cover change (LULC) at BFRBS and the effects of anthropogenic activities on biodiversity conservation using BFRBS in Ghana. The study employs Landsat images from 1986, 2012, and 2020 to analyze the changes that have occurred.

2.0 Materials and methods

2.1 Study area

Bobiri Forest and Butterfly Sanctuary (BFRBS) is a 25-minute drive from Kwame Nkrumah University of Science and Technology (KNUST), Kumasi on Kumasi-Accra Road it is situated about 4 km off the main Accra road. This resource is managed by the Forestry Research Institute of Ghana (FORIG) and consists of tall and ancient trees. It was created in 1939 (Eshun, 2021). It is within the Tropical Moist Semi-Deciduous Forest and lies between latitudes 6° 40' and 6° 44' North of the Equator and longitudes 1° 15' and 1° 22' West of the Greenwich. The total area of the Reserve for ecotourism is 55.040 km² (21.1 sq. miles) along the road (Eshun & Asiedu, 2021). The Reserve is also rich in biodiversity, flora (80-100) plant species per acre with about 120 bird species that have been identified in the BFRBS.

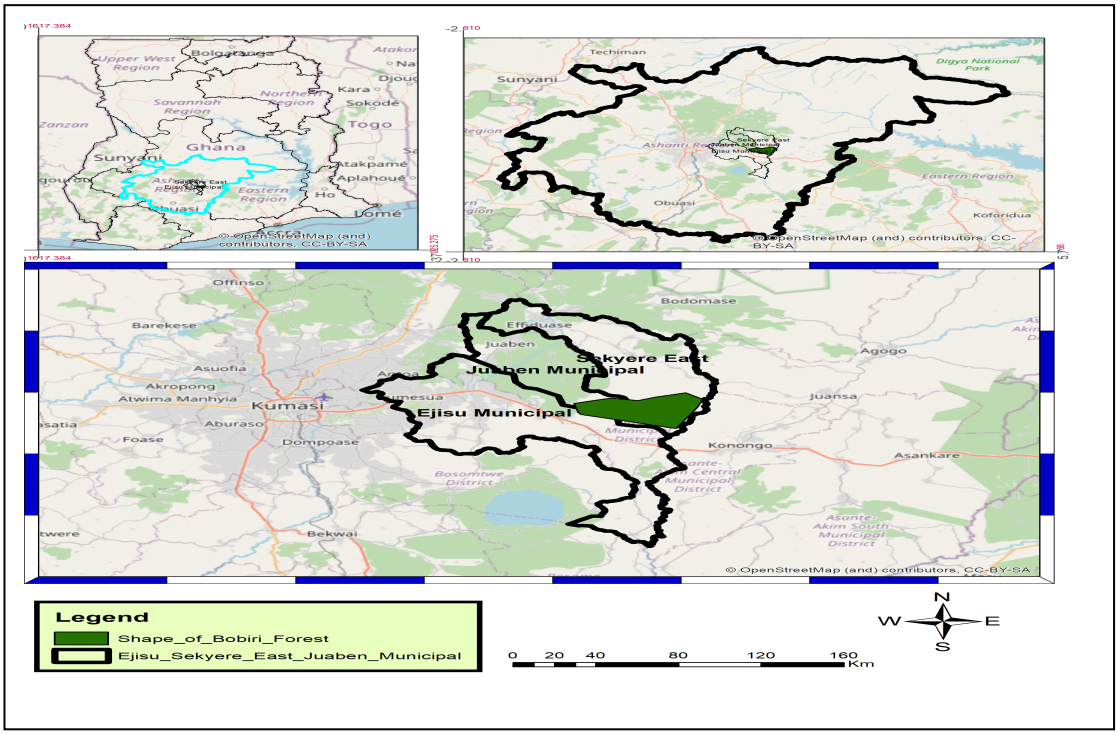
In 1936, the Juaben Stool lifted a ban on farming within the reserve which increased farming activities in the reserve. From 1945 to 1950 the Forestry Commission (FC) devised a working plan to reinstate the ban to prevent the exploitation of the reserve which led to the demarcation of the reserve into productive, conversion, and conservation areas. A tree nursery was started in the reserve by FC between 1948 and 1960 and was later converted into an arboretum which helped in realizing the richness in diversity of species in the area. A butterfly sanctuary was introduced in 1995 and became an ecotourism site in 1996[2].

The BFRBS is noted for its rich biodiversity which has led to its development as an ecotourism destination to ensure the integrity of the resource (Mensah & Ernest, 2013). The BFRBS consists of 1417.22 (Ha) of potentially protected forest, potentially productive areas

[2] https://csir-forig.org.gh/2-uncategorised?start=27FC

are 4021.18 (Ha), and admitted farms of 65.60 (Ha) as outlined in the Forest Service Division. Logging activities are carried out in the productive areas. Research conducted by (Mensah & Ernest, 2013) reveals that there has been development in the communities around the forest because of ecotourism activities. (Edusah, 2011) posits that community members around BFRBS sneak into the forest to harvest forest and non-forest products. Such anthropogenic activities have implications for biodiversity conservation.

area. It is the time of the year before the onset of the dry season. Landsat images were used because they can provide data spanning as far as 1970 (Baffour-Ata et al., 2021) and it's equally good for detecting small areas of degradation since the pixel size is 30 meters as compared to the average farm size of 0.3 acres (Acheampong et al., 2018).



The image selection was based on the availability of the image, low cloud coverage, and quality (Baidoo et al., 2023).

2.2 Methods

2.2.1 Aerial imagery acquisition

To investigate the LULC within BFRBS, Landsat TM5 and ETM+ images were downloaded from the US Geological Survey website (USGS.gov) in July 2021. The images were captured in December 1986, 2012, and 2020.

2.2.2 Image processing and analysis

ENVI 5.3 and ArcGIS 10.3 were used for image preprocessing and processing activities. The scan lines on the 2012 and 2020 images were removed using ENVI (Fix Landsat 7 Scanline Error). The images were calibrated to get rid of satellite artefacts and geometric inaccuracies since (Gaunter et al., 2007) posit that satellite images may not be accurate due to errors in spectral reflectance that can shift normal band positions and it is important to remove the errors and correct the image by calibrating the images. Atmospheric calibrations used was the FLAASH algorithm. Six (6) multispectral bands were stacked into the composite image but bands 3, and 4 were used in performing the Normalized Difference Vegetation Index (NDVI) for assessing vegetation vigour. These bands were used because they allow vegetation to be distinguished clearly. To enhance visualization and interpretation, false colours were used to assist with the identification of the images (Acheampong et al., 2018).

2.2.3 Image classification

The machine-learning algorithm of supervised image classification was performed to understand the true reflection of the land use/ land cover on the ground. Pixels were assigned to different classes of land use and land cover that were identified in the study area. Already familiar with the land use patterns in the study area, four different classes were considered. These are 1. forest (primary, secondary, mangroves), 2. grassland, 3. farms (vegetable lands, crop fields), and Built-up areas (residential areas, roads, and paths). Both true and false-color compositions were used to determine the various land cover classes using the Google Earth engine (Biney & Boakye, 2021) which provided an overview of the real-time situation of the classes. NDVI was also used to distinguish between vegetated areas and non-vegetated areas and determine the health of the vegetation (vegetation vigour). NDVI mask was created to show real vegetation and degraded areas since the area was supposed to be a forest reserve. A threshold mask of below 0.2 and 0.2 or above was used to show non-vegetated areas and vegetated areas respectively. The NDVI was calculated using the formula (b1-b2)/(b1+b2) where b1 is Landsat band 4 and b2 is Landsat band 3.

2.2.4 Accuracy assessment

The GPS device was used to pick some points within the reserve which was loaded on the image to see where they fall. The colours on which they fell were used to define ROIs that were used to perform supervised classification. To check whether areas were selected to be primary forests, grasslands, farms, and built-up areas, several points were created on these images on the map and loaded in Google Earth and a 2020-time image was used for verification. These points were zoomed in to verify whether they fall in their respective areas. More than 60% of the points fell into their respective classes. Total, user, and producer accuracies were calculated for the three-year images used for the study.

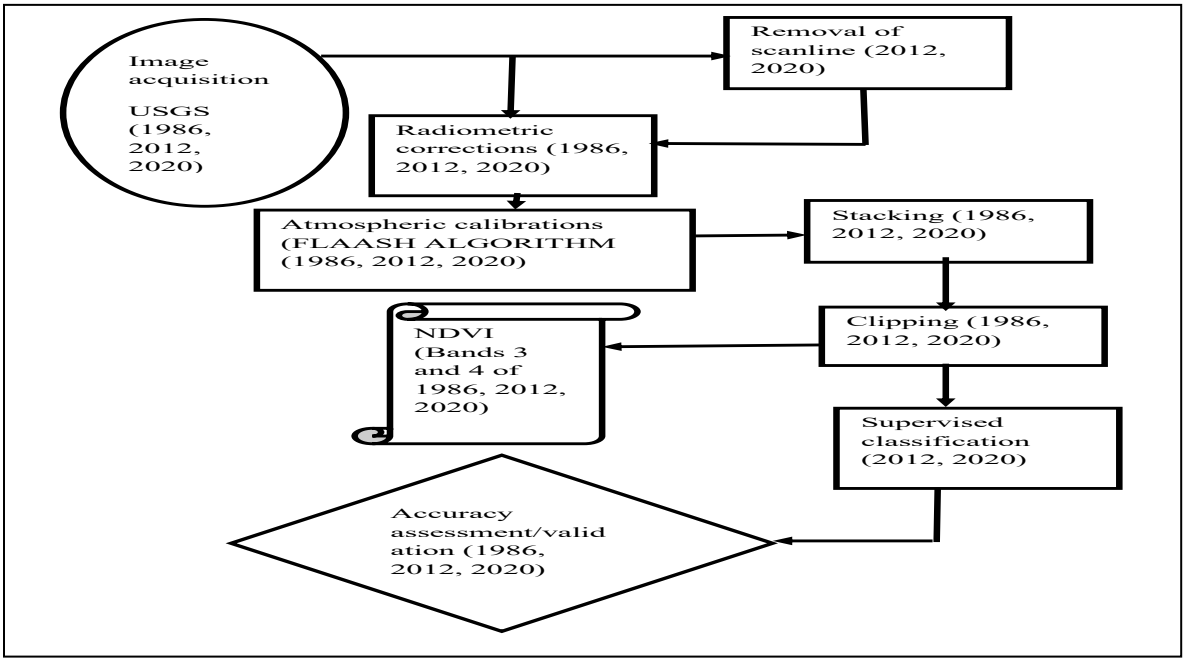


Figure 2: Methodological flow chart

2.2.5 Interviews

The snowball technique was used to interview 7 community members who have lived in the community for over 40 years. The manager of the reserve at the time of the research was also interviewed. The results were analyzed using content analysis.

3.0 Results and discussions

3.1 State of BFRBS 1986-2020

The state of BFRBS was analysed using the NDVI which was performed to check the health of the forest and the result is that deep green areas show very green vegetation, and white shows areas where there is no vegetation or less vegetation. The BFRBS shape shows a denser forest (primary forest) at the eastern side and the middle belt in the 1986 image than the 2012 image. Increasing from -1 to +1 shows areas of bare soils to deep vegetation. The 1986 NDVI image shows less green at the western side whilst that of the 2012 image has patches of less green at the eastern side. Total vegetation cover for the 1986 image is 522.6 sq. km and non-vegetated areas cover 43.1 sq. km whereas vegetated areas in the 2012 image are approximately 544.6 sq. km and non-vegetation areas are 21sq.km. The 2020 image has more vegetation than the other years with a vegetation cover of approximately 559.1 sq. km and non-vegetated areas constitute 6.5 sq. km. These images are shown in Figures 3 to 5.

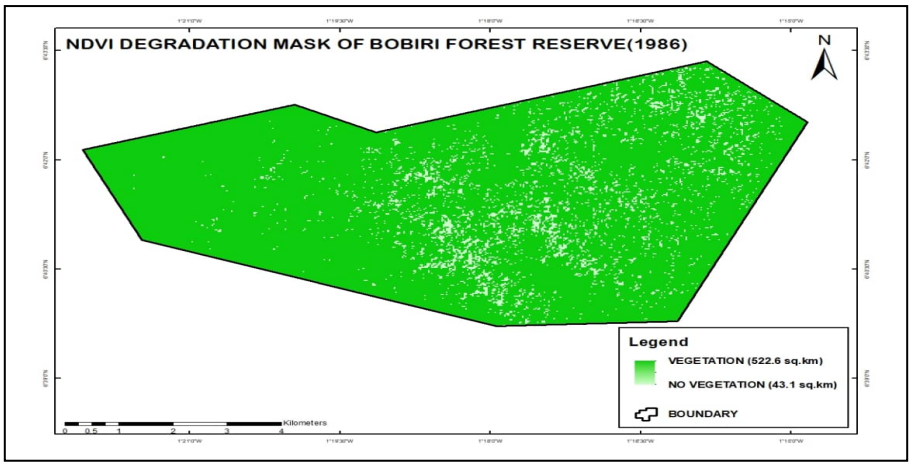


Figure 3: NDVI 1986

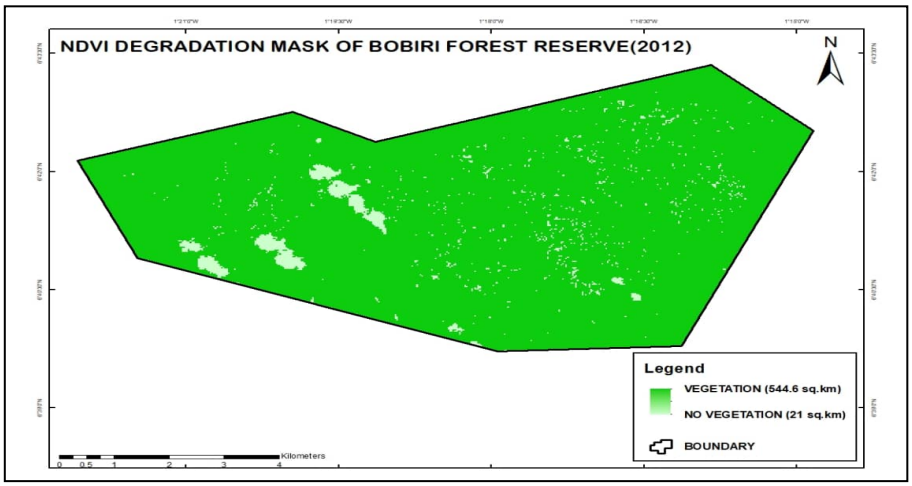


Figure 4: NDVI 2012

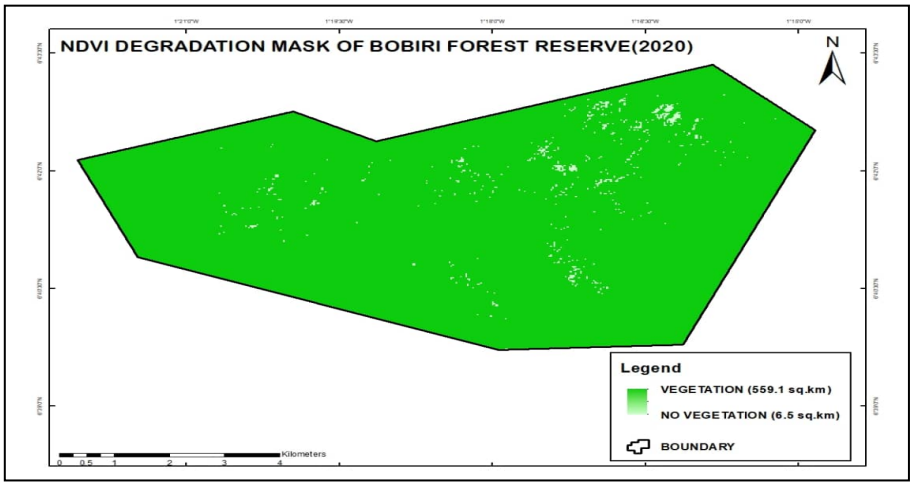


Figure 5: NDVI 2020

Table 1: Percentage change

Year/Class	1986-2012	2012-2020
Forest	4.5%	-1.1%
Grassland	-46%	34%
Farms	937%	-70%
Built-up	0	0

Land use and land cover (LULC) maps generated indicate that there was an increase in forest cover from 1986 to 2012 from 499.23 sq. km to 521.694 sq. km. However, there was a reduction to 515.529 sq. km in 2020. Grassland reduced considerably from 65.583 sq. km in 1986 to 35.523swq.km and increased again in 2020 to 47.592. Farmlands increased from 0.81 sq. km to 8.406 sq. km from 1986 to 2012 and reduced to 2.502 sq. km in 2020. There were no built-up areas within the forest reserves for the years under study. Farming activities remained the most dominant land use type between 1986 to 2012. The percentage change is shown in Table 1.

LULC maps for these years confirm the dominance of forests as the mainland shows more green vegetation in 1986, 2012, and 2020 images and this is not surprising since the area under study is a forest. The 1986 image shows more grassland in the eastern section of the reserve with slight red spots indicating farmlands on the southern side of the reserve. Even though it is not expected that a forest reserve should have farmlands within, the 2012 image showed an increase in farmlands in red colours mostly in the eastern part of the reserve and a few in the southern part of the reserve. Grassland also increased mostly around the reserve at the southeastern part of the reserve. The 2020 image shows the concentration of farmlands around the southern sector of the reserve with increased grassland around the entire reserve especially at the southeastern, southern, and southwestern sections of the reserve. These are shown in Figures 6 to 8.

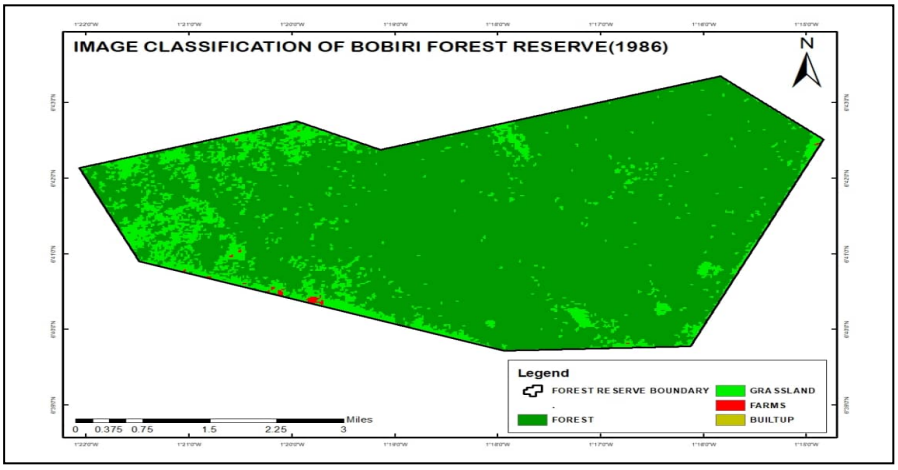


Figure 6:1986 Image classification of BFRBS

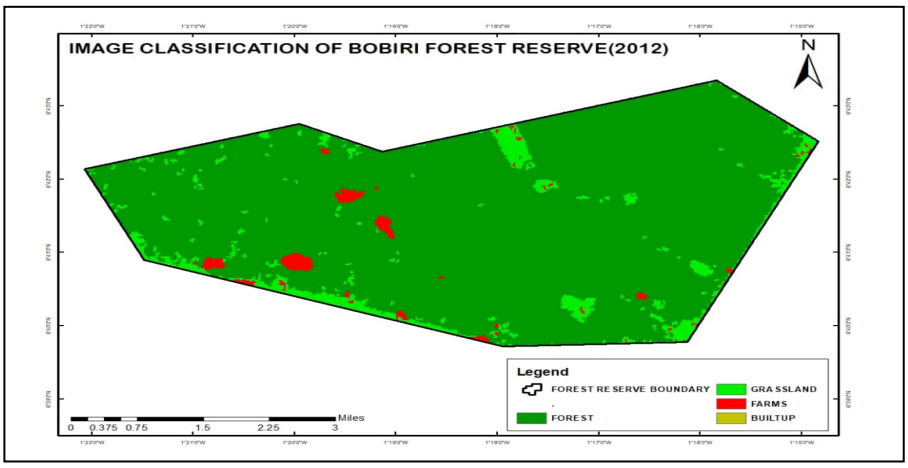


Figure 7: 2012 Image classification of BFRBS

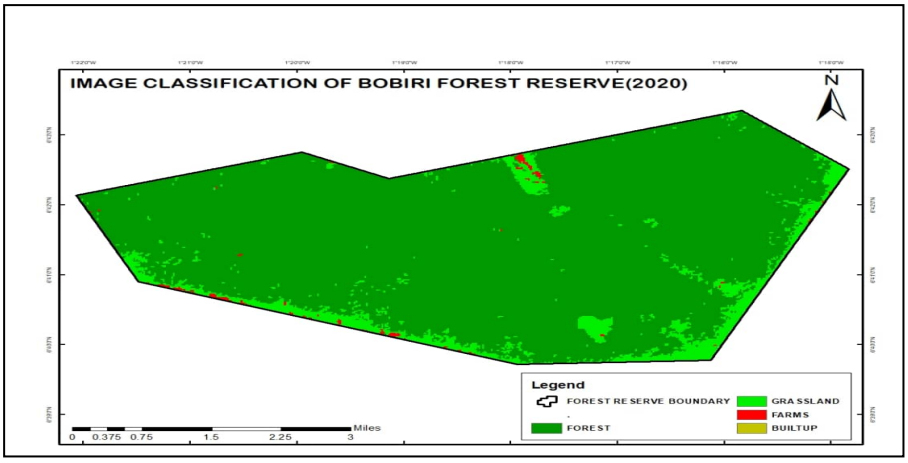


Figure 8: 2020 Image classification of BFRBS

Producer and User accuracy

Land use land cover change compared with reference data showed estimated overall accuracy of 76%, 72%, and 72% in 1986, 2012, and 2020 respectively. There were different levels of agreement with the producer and user accuracies as shown in Table 2.

Table 2: Producer and user accuracy

Year/Class	**1986**		**2012**		**2020**	
	Producer	User	Producer	User	Producer	User
Forest	67%	67%	47%	100%	67%	100%
Grassland	91%	83%	63%	71%	63%	63%
Farms	63%	71%	100%	33%	100%	56%
Overall accuracy	76		72%		72%	
Kappa Coefficient	0.847					

Results from interviews with the management of the forest reserve revealed that there were some admitted farms within the reserve before the beginning of ecotourism activities. Even though there had been a ban on farming in the reserve, this ban was lifted around 1989 which increased farming activities in the reserve. Such activities might have contributed to an increase in grasslands since cleared farms allowed to fallow can be occupied by grass. A tree nursery was carried out in the reserve to boost the quality of the forest and enhance ecotourism activities.

This has also contributed to the increase in the forest from 1986 to 2012. Interviews with some community members who have lived in the community for over 40 years revealed that some of the members have their farms around the forest reserve.

Respondents said they have their farms close to the forest. This might have contributed to the growth of farmlands around the forest reserve in the 2020 image especially in the southeastern part of the reserve. The manager of the park said the community members are occasionally engaged in educational programs about ecotourism activities and the need for them to protect the reserve. Community members on the other hand also complained of not receiving financial benefits from the ecotourism activities and added that some people engage in illegal logging within the reserve. They continued that grass has occupied some portion of the production section of the forest an indication that, logging activities in the area are not accompanied by replanting

exercises which could explain the reduction in forest cover from 2012 to 2020.

Discussion

Changes in land-use patterns within the forest reserve can largely be attributed to human activities. As noted earlier, the conservation of the area was initiated by the richness of the biodiversity in the area. However, the management of the reserve had to devise certain strategies to boost the conservation of the resource hence engaged in tree planting which increased the forested areas within the reserve. Such positive anthropogenic activities tend to enhance biodiversity conservation and should be encouraged (Baidoo et al., 2023; Eshun et al., 2022). However, logging at the production section without any deliberate efforts to replant can reduce forest cover as timber extraction is noted to be one of the key factors contributing to biodiversity loss (Gatti et al., 2017). Illegal logging activities in the forest also have implications for biodiversity conservation. Some authors who have investigated the BFRBS have found that there are illegal activities that go on within the forest. For instance, (Eshun & Tichaawa, 2020) posits that community members around Bobiri Forest engage in illegal activities within the forest. Baffour-Ata et al. (2021) also observed that communities around BFRBS exploit livelihood resources from the forest. Such illegal activities in the forest can reduce the forest land cover used for ecotourism activities and could be reduced if residents have alternative means of survival. Human actions can improve or reduce biodiversity and major biodiversity loss has been attributed to human activities (Anwar et al., 2021; Arora, 2018; Jahan et al., 2021; Luque et al., 2018). Increased population also exacerbates biodiversity loss as it puts pressure on the resources (Baidoo et al., 2023).

People want to enhance their economic base and their livelihood sources. Since community members are encouraged to stop farming in the reserve, to give room for ecotourism activities, their sources of livelihoods would be affected. Aik et al. (2021) noted the complex nature of the relationship between land use and human growth. People exploit their immediate surroundings for survival. The tenets of ecotourism outline that, for ecotourism to be sustainable, the economic, social, and environmental benefits of the reserve should be maintained and the residents should be empowered humanly, socially, economically, environmentally, and politically (Eshun & Asiedu, 2021).

When the benefits of ecotourism are balanced, community members will receive economic incentives which will keep their interest in preserving the resources to boost ecotourism (Eshun et al., 2022; Eshun & Asiedu, 2021). The study findings indicate that the loss of forest cover is largely attributed to negative anthropogenic activities and positive anthropogenic activities can enhance biodiversity conservation. Positive strategies can help preserve forest resources and enhance forest land use within the forest reserve (Baidoo et al., 2023). Strategies such as plantation programs in the reserve have proven to have positive effects on the forest land cover whilst illegal activities by residents within and around the reserve (Baffour-Ata et al., 2021; Eshun & Tichaawa, 2019) reduce the forest land cover. Providing incentives for community members around forest reserves is critical for biodiversity conservation.

Conclusion and Recommendations

This paper examined management practices that can influence biodiversity conservation

using remote sensing techniques and found that there have been changes in the BFRBS from 1986 through 2012 to 2020. These changes include both the loss and gain of forests, grasslands, and farmlands as a result of anthropogenic activities. The study concludes that the conservation area used for ecotourism activities has had a positive effect on the reserve whereas illegal activities, lumbering without planting new trees have contributed to the loss of forest cover in the reserve. It also concludes that the plantation programs engaged by forest management have also had a positive influence on the conservation of biodiversity in the reserve.

Based on the above conclusion, the research recommends that community members farming around the reserve should be involved in biodiversity conservation programs. They should be provided with seedlings to plant within their farms. Management of the reserve especially the Forestry Research Institute of Ghana (FORIG) should also plant more trees on the grasslands within the reserve to enhance the forest cover and preserve the forest biodiversity. Consensus should be built with the Forestry Commission and lumbering firms to engage in the replanting of trees. Community members should be provided with incentives and engage in alternative livelihood practices to stop illegal activities within the reserve. Management of forest resources should employ innovative techniques such as RS/GIS to constantly monitor the forest so that the necessary strategies can be employed in time to reduce forest loss.

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Women Participation in Drumming in the Northern Region of Ghana

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Abstract

This study specifically explored the cultural, social and spiritual factors that deter women from participating in traditional drumming practices in Bawku-Natinga. Data was collected through in-depth interviews and observational studies with 30 selected members of the Bawku-Natinga community. The study revealed the community's beliefs regarding women's participation in drumming, highlighting the spiritual connotation of drums, the perceived adverse effects of women touching drums and the embedded gender roles that influence these activities. The study not only uncovered the underlying reasons behind the lack of female's participation in drumming but also proposed tangible strategies to challenge these entrenched beliefs , including instituting training for talented women in the ensemble who are willing to take up drumming roles.

Keywords: Drumming, rituals, customs, gender and spiritual connotations.

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Introduction

Women, world over, play significant role in the socio- economic development of every society. This can be realized from what they do right at home and in the society where they live. In an article shared by Renne (2004) about the role of women in the family, she mentioned:

"The woman performs the role of wife, partner, organizer, administrator, director, re-creator, disburser, economist, mother, disciplinarian, teacher, health officer, artist and queen in the family at the same time."

On the contrary, she thinks today, civilization and societal change are motivating woman to leave the narrow sphere of the family circle to work with their full potentials outside the family for the enrichment of society. This means that women in society can assume some functional roles of men provided they are capable.

In a typical African society such as Ghana, one would not hasten to say music is an essential component of the way of life because there is no part of its human activity without music, in which men, women and children participate. For instance, during festivals, parties, funerals, enstoolment and other social gatherings, the presence of music cannot be overlooked. African music has many uses and as a result does not only function as an accompaniment to the various activities in the community, but also for entertainment during games and storytelling (*Osibi-asa* in wrestling among the Coastal Fantes and *Mboguo* in *Anansesem* among the Akans). This is why Nketia (1963) opine, music has a social role and this is seen in the following areas of human undertakings throughout the ages. Music has been an integral part of worship, in praise and in supplication to God or the gods. The importance of music in African traditional religion particularly is borne out in the saying. "The gods will not descend without music."

This is an indication that many stages in the life of man in the African setting are marked with the performance of music, for instance the rites of passage (Birth, Puberty, Marriage and Death).

Even though the contribution of female in music making is of paramount importance in all musical settings, their roles in drumming in Africa are very limited as compared to the female's participation in drumming in the western world. Females play active roles and contribute well to both instrumental and vocal music in the western world irrespective of the instruments involved, be it a drum. For instance, "Turtle Women Rising" is a women's ceremonial band as an organization. Turtle Women Rising exists because of a woman's vision. They mentioned:

"We stand with the endorsement of women elders and we provide an invitation for the women to return to their ceremonial roles by tending to the drum."

According to them, their core team is women with 25 or more years of walking with the drum and raising their voices in song and celebration to tend the fire, the spirit of the divine feminine, and the spirit of life. It has been observed that, in some communities in Africa, when it is time for playing instruments during traditional musical performances, it is only the men that are allowed to play the drums with women relegated to background. If there should be any role at all, it is the hand clapping and chorus singing.

Again, in Africa, women in the society were seen as housewives, bearers of children, traders and farmers. Traditionally, the childbearing ability of women is described as the means by which

lineage ancestors were allowed to be reborn. Further on, since agricultural production or farming was the main economic activity in many indigenous African communities, women worked on the farm often. As a result, the profit made financially as benefit for engaging in farming was used to keep or run the home, while those economic benefits accrued by the men from their engagements were either invested or put into ventures that were alleged to be that of the extended family. This ideology of how wealth was managed in the indigenous homes of some African communities made men to be seen as superior to women. By virtue of this, drumming among other things which is seen as a major role in music making in these communities is assigned to men only. While dancing, singing and clapping being the minor ones were assigned to women.

Furthermore, in Africa, drums used in ensembles were carved or constructed in the local communities by experts of traditional music and dance. They use skins of cow, goat, sheep or and antelope as well as wood and nylon strings. This construction sometimes goes through spiritual rituals by soaking the drum skin with some leaves which prevent women from touching because they are seen to be impure due to their menstrual cycle. Meaning, from the onset, these women don't have the opportunity to touch these drums, let alone playing.

The predominant instruments used in Africa are Membrnophones and ideophones. Some of these membranophones such as *Donno* (a double-headed hourglass shaped) found in Akan and some northern communities in Ghana are melodic as well as rhythmic (Amuah, Adum-Atta & Arthur (2004). Drummers control a *Donno's* pitche by cuddling and releasing the strings that go from one drumhead to the other, usually under the armpit. Changes based on the intensity of pressure on the strings affect the tension on the drumheads and determines the pitch production when the drum is stroke. It can be noted that, one's arm segment from the shoulder to the elbow naturally presses in on the upper rear section of the *Donno* strings. Although the upper arm is not the most important source of pressure on the *Donno*, it is part of the technique. For other types of membranaphones, found in Ghana such as *Patia*, *fɔmtɔmfrɔ, Atimevu*, *Apetema etc.* have shapes that do not need cuddling and releasing. They are either played with the palm or a stick to alter the sound produced. All the playing techniques described above involved in playing these drums demand so much strength and energy to produce a good rhythm and sound. Women on the other hand who are regarded as a weaker sex as compared to men in the African indigenous setting are not allowed to participate in drum playing as a result of the gravity of energy involved.

Apart from all these subjects raised earlier, the issue of gender has affected the role women play in the African traditional society. Johnson and Kolodney (2005) say that socialization occurs as boys and girls are exposed to different model and learn what is appropriated for each gender. This process starts at birth where the immediate parents or guardians are the first people to teach gender roles. It continues in the pre-school years through Junior High School, Senior High School and even in the Universities. Nketia, (1982) is of the view that,

"Takada dance drumming which comes from the Anlo-Ewe people of south eastern Ghana was a music that symbolizes a historic struggle of Anlo-women to excise their human right to free speech. Traditionally only men were given the opportunity to be the spokesperson, composer and the choreographer of African rituals. Women were expected not to argue with the men for the right to participate in the formation of these rituals. Drum playing was the central medium of communication among the Anlo-Ewe people."

So far as women were denied of their access to drumming, they were being denied the right to communicate through same medium. The same way women in Bawku-Natinga were deprived from playing drums to music meant for them. A typical example is the *Tora* music which is meant for women but the drums played by the men. This was confirmed by Agordoh (1994) who established that, *Tora* was a *Dagomba* women's musical type. Presently, it is performed all over Northern Ghana, specifically, the *Maprusis, Nanumbasa* and *Dagombas*. Though a recreational dance, it is however performed at funerals and other occasions like marriage ceremonies, public durbars, festivals and visit of state dignitaries. Although, the performance of *Tora* is strictly a women's affair, men also take part by playing the musical instruments. Another observation was made by Manuh (1998) who said, while many musical instruments are played exclusively by men, women often provide the voice of Africa's music. This legacy carries on from traditional to contemporary music and many of today's most popular singers in Africa are women. She also states that:

"women musicians have not made notable achievements as regards to playing instruments. Lack of personal time, educational resources and encouragement has greatly contributed to women not playing instruments."

Mastering a particular instrument needs time to study it and rehearsing almost every day. Meanwhile, from preliminary interview, the researchers gathered that, it is not easy for women to get someone who is willing to teach them how to play drums. Also, lack of resources-instrument and venues where rehearsals can take place has been another stumbling block for women as regards learning how to play drum. Essandoh (2006) remarked on this subject after he observed that, Ghanaian communities are made up of both men and women, young and old on which basis music is organized but there are certain things reserved for men only. The contribution of females to music making as far as instrumental roles are concerned is very minimal and limited to only vocal music. He said females have been exempted from the playing of instrument such as membranophone, chordophones and aerophones. Basically, the tradition of Northern Region of Ghana frowns on the handling and playing of drums by women. Acquah (2008), quoting Nzewi (2003) makes reference to the same cultural experience that " in the maiden's musical group of women in Africa, men play drums for them. He states that other scholars such as Nketia (1963, 1968, 1989), Maultsby (1990) and Gourlay (1982) have given the same exposure to African musical instruments, stressing the roles of men and women in the sociocultural context of the African community. It is becoming uncertain the factors militating against the participation of women in drumming in Northern Region of Ghana. It is also not known the perception of the masses about women participation in drumming in the communities and the

sociocultural impact that would be made when women participate in drumming. In view of this, study intends:

- to investigate the factors that had led to the non-participation of women in drumming in the Northern Region.
- to find out the community's opinion on drumming among women in the Northern Region.
- to investigate the possible means to erase the perception about women involvement in drumming.

Method

Research Design

The study used a qualitative research paradigm with a case study design. This design allowed the researchers to collect data in the natural setting of the participants. For Yin (2003) one of the considerable situations to use a case study in research is when the study wants to answer "how" and "why". Case study is a more flexible and dynamic research design, thus, its flexibility helped to address research questions in this study. These research questions were:

1. Why are women not allowed by to play drums among Bawku-Natinga?
2. How can the perception and superstition about drumming among women in Bawku-Natinga be erased?
3. What will be the sociocultural impact if women are allowed to take part in drumming in the Northern Region community?

Study Area

Bawku municipality is one of the nine districts in the Upper East Region found in the Northern part of Ghana. It has a total land area of about 1215.05 sq km. It shares boundaries with Burkina Faso, the Republic of Togo, Bawku West District and Garu-Tempane District to the North, East, West and South respectively. Bawku is the capital of the district, while Natinga is a sub-community in Bawku District with an estimated total population of about 205849 people. Natinga has (10) ten sub-chiefs who help in administrating duties within the area.

Study Population

The participants of this study include sub-divisional chiefs and some subjects of the Bawku-Natinga community. In all, thirty (30) people participated in the study. Ten (10) individuals were interviewed, that was, sub-chiefs and a subject in each area. Five (5) sub-chiefs were chosen where another five (5) females were also chosen from the area of authority of each of the five sub-chiefs. Furthermore, twenty (20) members of *Tora* local ensemble in the area were observed.

Sample procedure

The method used in sampling was the cluster approach. This was because the area of study was large with ten (10) areas made up of sub-chiefs. The cluster sampling method was very instrumental in the selection of five electoral areas for the study. This was achieved by grouping the ten (10) electoral areas into five clusters within which an area was picked from each cluster using simple random sampling. In addition, a quota sampling was used in selecting a sample size. The procedure used for selecting a 'quota' of respondents to be chosen from the

population was the drawing of a sampling frame across the five random selected electoral areas (out of the ten) which was used to select respondents on the basis of quota allotted to each electoral area. With this, two (2) respondents each were selected in the electoral areas being a chief and a female subject. Finally, a purposive sampling technique was applied by concentrating on *Tora* ensemble made up of twenty (20) members, five (5) males and fifteen (15) females.

Data Collection Instruments

The main instruments used for data collection were interview and observation. The interview schedule for the respondents was divided into three (3) sections which covered women participation in drumming, the role of women in the ensemble and suggestions as to how to erase the view of gender difference, perception and superstition around women's participation in drumming. Meanwhile, the researcher observed by visiting rehearsal sessions and performances of a *Tora* ensemble to study and find the distribution of instrumental roles in it, the way the local people in Bawku-Natinga organize their indigenous music and the active role females play in the making of the music in the community. These data collection instruments were necessary because they helped the researcher to establish the facts done within, five months- December 2021 to April 2022. The first step in the phases structured for data collection in the study was done by chatting and having an informal interview with the sub-chiefs, who were locally known as *Gbadana* and some subjects of Bawku-Natinga. This was done by visiting them in their individual homes, just to establish good rapport with them. The second phase was the researchers' formal interview schedule, where relevant information was gathered regarding the study. This was done between 27th December 2021 and 10th January 2022 at the homes and work places of respondents. Furthermore, between 12th and 20th February 2022, the rehearsal section of a *Tora* ensemble was observed. Information obtained were consistently cross-check to obtain consistency in data collected.

Results and Discussion

The researchers made a field trip to the rehearsals of the *Tora* ensemble in month of December 2022 and January, 2023 which was the normal rehearsal time for the ensemble. It was formal rehearsal, because it took into consideration the laid down procedures and structures that governs their meeting or rehearsal. The people present were the dancers and the singers who were females and the instrumentalist who were males. The rehearsal was an hour activity which took off every Saturday between 3 and 4pm. This was very suitable for the women because they were able to finish early and go back to attend to their house hold chores.

Before the rehearsal started the main cantor paid homage to the instrumentalist by kneeling down in front of them. When she returned, she started the opening warm-up song which was soon taken over by the other singers and dancers. From observation, *Tora* was a game-like music in which two dancers knock their buttocks together in time to the cadence moment in the drumming. Each dancer knocked twice. The dancing was reserved for the women because they were seen to have more flesh at their buttocks and could make the dancing

attractive. Another role played by women was to sing songs on call and response format because songs formed an essential part of *Tora* music. The women used all kinds of vocal techniques prevalent to the northern part of Ghana; that is glides, glissando, nasal voice quality, melismatic treatment of text among others on in their repertoire. They were assigned the singing because of their melodious voices.

The researcher realized that, there was also clapping of hands which was mainly done by women. The handclap in *Tora* functioned as a musical time line. This time lines shaped the rhythmic contour of the music and provides an important rhythmic partner for each part. For example, the dancers' steps were timed in unison with the handclaps.

Instruments used in the dance were basically the *guŋgoŋ*, the *Lunŋa* and hand clapping. Two *guŋgoŋ* were used in *Tora* music which were all played by men. The source of sound of the two drums was the membrane. In *Tora*, the two *guŋgoŋ* drummers either played in unison, or one drummer chooses to repeat basic variations while the second drummer plays a more intriguing solo. The *Lunŋa* (a double-headed hourglass shaped drum), also called *Donno* by the Akans of Ghana, unlike the *guŋgoŋ,* the frame is curved. The curved nature of the wooden frame of *Lunŋa* gives a change of sound when a player compressed and released with the arm under the armpit. The source of sound was the membrane where curved sticks were used in playing. Women were not allowed to play because of the energy involved in playing.

From the interview, respondents expressed different views on the reason why females were not allowed to participate in drumming in Bawku-Natinga. When asked whether women play drums in the community, all the respondents said no. The following reasons where given.

A respondent said:

" The reason why women are not allowed to drum is that, since time immemorial, men are the ones seen playing drum and so people in the community see it as the responsibility of men to drum."

For Abugre,

"Women are not allowed to play drums because they are seen as naturally weaker than men."

Madam Yenti Mariam, a female respondent, disclosed that, lot of situations abounds in the Northern traditional areas where music is required. She stated that, of relevance to the women is the phenomenon of singing and dancing. Although songs and dancing add beauty to music making in the Bawku Natinga, they had value and more important effect of curbing recalcitrant and criminal minded members of the community and so to her, the women do not touch the drums at all. According to an interviewee, women were not allowed to play drums in the Bawku-Natinga community due to some prevailing tradition and customs. She stated that it is a very big taboo for women to drum and it is also against the customs and the tradition of the area of the study. It is belief that when a woman plays drums, there are going to be spiritual dangers which would affect any victim for the rest of her life. She said failure to obey these rules can lead to swelling of any woman who touches the drum.

The findings brought to light that, there has been a perception and superstitious connotation around women and drumming from the past. The researchers were made aware that, there is an impression that, females that play musical instruments would have a non-stop menstruation. It was alluded that, this act continues (Menstruation) until the person involved dies. It is belief that drums have spiritual powers which apart from the abnormal menstruation, are capable of making women suffer unusual abdominal pains. It was gathered that; this may even lead to life time barrenness. More so, there is also an ideology that females who would be involved in drumming would develop a very big testicle (locally called *pua*) which originally is a part of the male genital organ.

Through an interview with one of the sub-chiefs (locally known as *Naaba*) in Bawku–Natinga, it was revealed that, women do not drum because they were considered not pure because of their menstrual circle. Drums were considered sacred, as sometimes even worshipped as gods. If a woman were to touch the drum, then she would cause harm to the drum and make the drum lose all of its power due to her impure nature. Therefore, women were not permitted to touch the drum. These myths hinder women from drumming hence for many years, women have been stereotyped as docile and meek individuals. More so, the rigid gender roles have disenfranchised women on a number of levels. Women were taught that drumming along with a number of other cultural and economic opportunities are out of reach because women do not have the capabilities to achieve them.

In an interview with another participant in Bawku-Natinga he said there are rituals that were performed before any performance in the olden days. This ritual could be harmful to a woman or the occasion when females play the drum. Another respondent reveals how some females had been discourage and prevented by their fellow males from taking active role in drum playing. Gender roles are natured roles and responsibilities conferred on either gender as result of the social constructs of respective societies. For example, in some societies, farm work could be predominately male responsibilities while in others it is accepted as woman's affair. A respondent stated that, in the community of Bawku-Natinga women had a peculiar role that is generally critical. She said it is appreciated when women act as agents of propagation of its genetic stock, preservation of its culture, cohesion of society and economic growth, respectively through birthing and nurturing of babies, up bring of the children, exertion of collective moral cohesive force for the common good, and partaking in socio-economic endeavours. Whiles the younger female children are trained exclusively to take care of the house hold chores, such as fetching water, grinding maize, cooking and caring for younger siblings, on the contrary the males are expose to the acquisition of musical knowledge and skills through exposal to musical situations created in the society in which he absorbs by active participation. The respondent said, even in some situations, it is the social role of the child to take over from his father or a relative in playing the drums or any instruments.

In order to erase the perception and superstition about drumming among women in Northern Region of Ghana, women should be exposed to drum training. This can contribute to enhance their ability to drum because it does not only take strength to drum but skills and techniques are required. To add, educating the public would be another good approach to erase the perception and superstition about women drumming. This is to say that the community should be enlightened about modernization and civilization where in the western world, women drum yet had not adverse effect. From another perspective, there are women who made significant contribution in academics, health care, finance, economy, education, and politics and so on. Apart from this, there are multitudes of women in the world in professions and callings who are daily making contributions that are helping the world much assuredly forward into globalized community of the 21st century, thus other women can use drum talents to also inspire and contribute to development.

It became evident in the findings that some respondents wanted some transformation where women would be given the opportunity to also exhibit their talent on traditional drums. This was indicated in the differences in the speeches of some women the researchers interviewed. Though greater percentage of the male interviewees complained about the women who now play drums in the contemporary world, a few buy the idea and recommended that women can now be trained to play traditional drums because of current civilization.

Also, some respondents opined that talented women can train on the traditional drum in order to perform without men. This, they said would enhance and showcase the talents and capabilities of women in the Bawku-Natinga community. On the contrary, there is the tendency of community pride and cultural continuity. According to investigation, the chief who was asked to comment on women participation in drumming said they respect and are very proud of their customs and traditions. In effect, there should be things reserved for men only in the community in order to make them superior over women. He said, they the men are ready to pass this tradition on from generation to generation.

Conclusion

The research has brought to light some of the traditional perceptions about women in Bawku-Natinga in terms of their involvement in the playing of drums thus identifying the impact if women are allowed to drum in traditional music making. Drumming which was associated with prestige was preserved for men considering the fact that man was seen to be brave and "holy". Moreover, this study has confirmed, the peoples believe that traditional drums were not to be played by women because of old rituals and custom. It is a very big taboo for women to drum and it is also against the customs and the tradition of the area. It is believed that when a woman plays a drum there are going to be spiritual dangers which would affect any victim for the rest of her life failure to obey this rule can lead to a swelling of any women who touches the drum. The researcher discovered that, in the community of Bawku-Natinga women had a peculiar role that is generally critical. In view of

this, it is rather appreciated when women act as agents of propagation of its genetic stock, preservation of its cultured, cohesion of society and economic growth respectively through birthing and nurturing of babies, up bring of the children, exertion of collective moral cohesive force for the common good and partaking in socio-economic endeavour rather than playing a role like drumming in traditional music setting in Bawku-Natinga .

Recommendations

Below are some recommendations to be considered:

1. Tora ensembles in Bawku-Natinga should institute the training of women in the ensemble who are talented and willing to take up drumming roles.
2. The chiefs and elders should institute occasions in bawku-natinga where women will mount the whole ensemble to display on the drums, sing and dance.
3. Proper documentation should be made on drum patterns of Tora to make learning easy for women.

Further research

It is relevant to propose some of the areas requiring further exploration

1. One major musical type identified and discussed in this work through observation, known as *Tora* provides a basis for separate in-depth study, thus the difference between traditional *Tora* dance and the contemporary *Tora* dance can be looked at.
2. Women contribute a lot in the social and economic sphere of Bawku-Natinga therefore the researcher will propose a deep investigation into the role of women in the sociocultural development of Bawku-Natinga community.

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