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Research

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Assessment of farm size, gender dynamics, and biosecurity practices in the incidence of Newcastle disease and avian influenza in indigenous chicken and Guinea fowl smallholder farms in Northern Benin

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Abstract

Introduction: *in the northern region of Benin, poultry farming is essential for livelihood and food security but is challenged by Newcastle Disease (ND) and Avian Influenza (AI). This study explores how gender dynamics and biosecurity practices affect the prevalence of these diseases in local poultry farms.* ***Methods:*** *a survey was conducted among 118 smallholder farmers (52 men and 66 women) to gather data on biosecurity practices, disease incidence, and farm demographics. The data were analyzed to identify relationships between variables such as gender, farm size, and biosecurity measures.* ***Results:*** *women predominantly managed small-scale farms (60.10%). Newcastle disease was reported by 49.15% of farmers, with symptoms including torticollis (43.10%) and greenish diarrhea (37.93%). Avian influenza was reported by 30.76% of farmers, with symptoms such as hemorrhagic comb wattles and legs (34.29%) and sudden death (25.71%). Vaccination against ND was practiced by 51.69% of farmers; none were vaccinated against AI. Significant relationships were found between gender and farm size ($p < 0.001$), biosecurity implementation and ND experience ($p = 0.027$), wild bird contact and AI experience ($p < 0.001$), and quarantine practice and AI experience ($p = 0.006$).* ***Conclusion:*** *the study underscores the necessity for enhanced biosecurity measures and veterinary services to control Newcastle disease and Avian influenza in Northern Benin. It emphasizes the importance of empowering female farmers through improved access to biosecurity resources, targeted training, and microfinancing. Experience with ND motivates preventive actions, whereas AI experience did not significantly impact biosecurity practices.*

Introduction

Poultry farming is a crucial element of the agricultural economy in many developing regions, including the Republic of Benin, where it stands as the second most important livestock sector after cattle [1,2]. It plays a significant role in providing livelihoods and nutrition for rural communities. For millions of small-scale producers, many of whom face financial hardships, poultry farming meets essential domestic and economic needs. The sale of poultry offers these rural households a vital source of cash income [1].

In Benin, the poultry sector is dominated by indigenous species, with Guinea fowl being the third most prevalent domestic bird after ducks and chickens [3]. Recent data from Benin's Agricultural Statistics Department (DSA) indicate that the country's poultry flock has grown substantially, with the indigenous chicken population reaching approximately 16.431 million heads in 2023, a 7.50% increase from the previous year's count [4]. This growth underscores the sector's importance in sustaining the livelihoods of many Beninese, particularly in rural areas.

Despite this growth, the indigenous poultry industry in Benin faces several challenges, including low productivity, poor biosecurity, and a lack of inputs. These issues are more pronounced among traditional smallholders who dominate domestic production [5]. Indigenous poultry farms are particularly vulnerable to diseases such as Newcastle disease (ND) and Avian influenza (AI), which pose significant risks to poultry health, public health, and the economic stability of the region [6]. Newcastle disease and AI are highly contagious viral diseases that can lead to severe morbidity and mortality in poultry populations flocks [7]. Effective control and prevention of these diseases rely heavily on stringent biosecurity measures, such as regulating farm hygiene, controlling access to poultry facilities, and managing farm inputs and outputs [8].

In Northern Benin, the traditional and extensive nature of indigenous poultry farming presents unique challenges for disease control. Smallholder farmers often lack the resources and knowledge needed to implement comprehensive biosecurity protocols [9]. Additionally, the scale of poultry farming and gender roles significantly influence management practices and the adoption of biosecurity measures. Women, in particular, play a critical role in poultry farming in this region, often managing small-scale operations that are especially vulnerable to disease outbreaks due to limited resources and access to information [10].

This study aims to assess the association between the poultry farms size and the gender, the current biosecurity practices among indigenous poultry farms in Northern Benin and the occurrence of ND and AI. By identifying gaps in biosecurity, analyzing the influence of farm size, and understanding gender dynamics, this research seeks to provide evidence-based recommendations to enhance disease control and improve the sustainability of poultry farming in the region.

Methods

Description of study sites: this research was conducted in Benin's Northern region specifically in the Atacora and Donga departments. The Northern region of Benin, which is situated above the central part of the country, extends towards the borders with Burkina Faso, Niger, Nigeria, and Togo. Geographically, it lies between latitudes 10° and 12°N and longitudes 1° and 3°E. Administratively, the Northern region of Benin comprises several departments, including Alibori, Atacora, Borgou, and Donga [11]. The Atacora department is situated in the north-western part of Benin, sharing borders with Togo to the west and Burkina Faso to the north (Figure 1). It comprises nine communes: Boukoumbé, Cobly, Kérou, Kouandé, Matéri, Natitingou (the prefecture), and Pehunko, covering an area of 20,499 km^2 with approximately 517 villages and town districts. The Donga department, which was previously part of the Atacora department, covers an area of 11,126 km^2 and includes the communities of Bassila, Copargo, Djougou (the prefecture), and Ouaké (Figure 1).

Study design: a multistage sampling approach was used to select farmers for the study. Initially, six districts (Bassila, Boukoumbé, Djougou, Kouandé, Natitingou, and Pehunco), known for significant guinea fowl and indigenous chicken populations, were purposefully chosen. Subsequently, farmers were randomly sampled from 118 smallholder farms using a simple random sampling method. This diverse sample included farmers of local chickens and guinea fowl across various age groups and genders, managing both vaccinated and unvaccinated birds, and those with birds appearing healthy or showing symptoms of Newcastle Disease (ND) and Avian Influenza (AI).

Sample size determination and sampling criteria: the number of smallholder farms (n) was determined using the Cochran formula [12].

$$n = \frac{Z^2 * p * (1-p)}{d^2}$$

The formula takes into account the desired level of confidence (Z score at 95% confidence interval), expected proportion (p), and margin of error (e). For this study; confidence level: 95% (Z = 1.96), margin of error (d) = 0.05 (±5%), expected proportion (p) = 0.0838 derived from the average prevalence of Newcastle Disease and Avian Influenza in neighboring regions of Togo [13], Niger [14], and Southern Benin [13] were used to estimate the sample size. The estimated sample size required was 118 smallholder farmers. Simple random sampling was employed to select smallholder farms. This process involved visiting various areas within the study region and randomly selecting smallholder farms on-site, ensuring that each had an equal chance of being included in the sample.

Data collection: the data collection process for this study involved a mixed-methods approach,

combining both qualitative and quantitative methods. To achieve the objectives of assessing the association between the poultry farms size and the gender, the current biosecurity practices among indigenous poultry farms in Northern Benin and the occurrence of ND and AI, a structured questionnaire was designed and pre-tested. The questionnaire was administered to 118 smallholder farmers in Northern Benin. This questionnaire gathered information on various biosecurity practices, including regular cleaning and disinfection of poultry houses, proper manure management, quarantine and isolation practices, and carcass disposal methods. Additionally, the questionnaire inquired about the farmers' knowledge of Newcastle Disease (ND) and Avian Influenza (AI), as well as their vaccination practices against these diseases. The study also documented the prevalence of ND and AI including outbreaks, morbidity, and mortality rates in the sampled flocks, noting common symptoms observed and any vaccination measures implemented by the farmers.

Data management and analysis: the data were entered into Microsoft Excel® 2019 and analyzed using STATA software. Descriptive statistics were generated and presented in tables. The data were categorized and summarized, with farm size and gender contributions analyzed through quantitative methods. Chi-square tests were performed to assess the association between farm size and gender, biosecurity practices, and the frequency of Newcastle Disease (ND) and Avian Influenza (AI). All statistical tests were conducted at a 5% significance level (95% confidence interval).

Results

Demographic profile of indigenous chicken and guinea fowl farmers in Northern region of Benin: the demographic characteristics of poultry and guinea fowl farmers in the Northern region of Benin are summarized in Table 1. The study sample consisted of 66 females (55.93%) and 52 males (44.07%). The age distribution of the farmers revealed that the majority were aged between 30-50 years (61.86%), followed by those aged 20-30 years (24.58%), over 51 years (11.86%), and under 19 years (1.69%). Regarding education levels, 38.14% of the farmers were illiterate, 44.92% had primary education, and 16.95% had secondary education. Employment status varied, with 47.46% of farmers being unemployed, 14.41% employed, 33.05% self-employed, and 5.08% retired (Table 1).

Demographic representation of indigenous chicken and Guinea fowl farmers in Northern Region of Benin: the Table 2 details the distribution of poultry farms by size and the gender of the farmers. Female farmers predominantly managed small-scale farms (less than 50 birds), accounting for 60.10% compared to 28.85% managed by males. Medium-scale farms (51-200 birds) were managed almost equally by females (34.85%) and males (46.15%). Large-scale farms (more than 200 birds) were primarily managed by males (25.00%), with only 4.55% of such farms managed by females (Table 2).

Biosecurity and management practices of indigenous chicken and guinea fowl farmers in the Northern region of Benin: the Table 3 details biosecurity and management practices among farmers. It shows that only 43.22% implement biosecurity measures. Cleaning frequency varies, with 38.14% cleaning as needed, 24.58% monthly, every two weeks 23.73%, and other frequencies less common. Manure management practices include spreading on fields (39.83%), selling (33.90%), throwing away (24.58%), and composting (1.69%). Quarantine practices are followed by 59.09%, while isolation of sick birds is practiced by 46.15%. Carcass disposal methods include open disposal (39.83%), burial (27.12%), giving to dogs (20.34%), eating (11.86%), and incineration (0.85%). Contact with wild birds is reported by 30.51% of farmers.

Knowledge and occurrence of Newcastle disease and Avian influenza in indigenous chicken and guinea fowl farms in the Northern region of Benin: knowledge and incidence of Newcastle disease (NDV) among the farmers are reported in Table 4. Nearly half (49.15%) of the farmers had experienced NDV in their flocks. The common symptoms recognized included torticollis (43.10%), greenish diarrhea (37.93%), respiratory distress and difficulty breathing (15.52%), and a drop in egg production (3.45%). Vaccination against NDV was practiced by 51.69% of the farmers. Additionally, only 30.76% of the farmers reported having encountered AI in their farms. The common symptoms identified included haemorrhagic comb, wattles, and legs (34.29%), sudden death (25.71%), coughing and sneezing (17.14%), diarrhea (17.14%), and respiratory distress and difficulty breathing (5.71%). Notably, none of the farmers reported vaccinating against AI (Table 4). The associations between various farm practices and farmer experiences were examined using Pearson's Chi-square tests (Table 5). The analysis demonstrated significant relationships between several variables: gender and farm size (χ^2= 16.2020, $p < 0.001$), gender and cleaning (χ^2= 16.2020, $p = 0.034$), biosecurity implementation and NDV experience (χ^2= 4.8624, $p = 0.027$), wild bird contact and AI experience (χ^2= 67.4475, $p < 0.001$), and quarantine practice and AI experience (χ^2= 7.6765, $p = 0.006$). Conversely, no significant associations were found between biosecurity implementation and AI experience (χ^2= 0.0154, $p = 0.901$), wild bird contact and NDV experience (χ^2= 0.8498, $p = 0.357$), outside bird purchase and NDV experience (χ^2= 2.6975, $p = 0.101$), or outside bird purchase and AI experience (χ^2= 0.1784, $p = 0.673$).

Discussion

The demographic profile of indigenous chicken and guinea fowl farmers in Northern Benin exhibits a higher proportion of female farmers (55.93%) compared to their male counterparts (44.07%). This finding aligns with similar studies conducted in sub-Saharan Africa, where women often dominate small-scale poultry farming due to its relatively low capital requirement and suitability for household-level operations [15,16]. However, a study by Dankwa *et al.* [17] in Northern Ghana revealed a contrasting trend, with farmers being predominantly male (83.3%). These regional variations in gender roles and participation in poultry farming across sub-Saharan Africa highlight the influence of cultural, economic, and social factors on the dynamics of small-scale poultry production.

The age distribution of the farmers in this study indicates that a significant majority of farmers, 61.86%, fall within the 30 to 50-year age bracket. This suggests a workforce characterized by maturity and experience, potentially enhancing their resilience and adaptability to farming challenges. This finding aligns with Moffo *et al.* [18], who reported that 70.1% of farmers were within the same age range, reinforcing the observation of a predominantly middle-aged farming population. In the current study, 38.14% of the farmers were identified as illiterate, which presents a substantial barrier to the implementation of biosecurity measures. Similar trends have been documented in other countries; for instance, studies by Ogunlade and Adebayo and Lawal *et al.* [19,20], in Nigeria revealed that a significant portion of the farming population, particularly women, lacked formal education, with illiteracy rates reaching as high as 88.3%.

The analysis of farm size distribution by gender reveals significant (χ^2= 16.2020, $P<0.001$) disparities: female farmers predominantly manage small-scale operations with less than 50 birds, whereas male farmers are more commonly associated with medium-scale (51-200 birds) and large-scale farms (over 200 birds). This gender-based disparity in farm sizes is likely attributable to differential access to critical resources such as land and capital. Men generally have greater access to these resources, which facilitates their involvement in larger-scale farming operations.

These findings are consistent with previous research by Abdirahman *et al.* [21], which highlights that men typically have better access to land, capital, and other essential resources required for expanding farm operations.

The study also revealed significant gaps in biosecurity among poultry farmers in Northern Benin, with only 43.22% following recommended biosecurity practices. Cleaning and disinfection are inconsistent: every two weeks (23.73%), monthly (24.58%), and as needed (38.14%). Manure management is also insufficient, with 39.83% spreading it on fields and 33.90% selling it. Disposal methods include open disposal (39.83%), burial (27.12%), giving to dogs (20.34%), consumption (11.86%), and incineration (0.85%), highlighting a lack of awareness or resources for proper disposal. Similar challenges in biosecurity practices were reported by Abdurrahman *et al.* [22] in Nigeria, where only 12% of poultry farms adhered to recommended biosecurity measures. The inadequate quarantine practices (59.09%) and isolation of sick birds (46.15%) further underscore the need for improved training and resources. Effective biosecurity measures are crucial for preventing disease outbreaks, as evidenced by Otieno *et al.* [23]. The prevalence of Newcastle Disease (ND) among the farmers' flocks was relatively high, with 49.15% of farmers reporting experiencing ND. Common symptoms recognized included torticollis (43.10%) and greenish diarrhea (37.93%). Vaccination against ND was practiced by 51.69% of the farmers, indicating moderate preventive measures. This is comparable to findings by Campbell *et al.* [24] in Tanzania, where 57% of poultry farmers practiced vaccination. Similarly, research by Otiang *et al.* [25] in Kenya and Ouma *et al.* [26] in Northern Ghana, and Central Tanzania, respectively, identified ND as a major concern on poultry farms, with significant efforts directed towards vaccination.

In contrast, the occurrence of Avian influenza (AI) was reported by only 30.76% of farmers, with symptoms such as hemorrhagic combs and sudden death being the most common. None of the farmers reported vaccinating against AI, reflecting a significant gap in preventive measures. Fatiregun and Saani [27], highlighted similar issues in Nigeria, where vaccination rates remained low due to cost and lack of access to vaccines.

This study examines the associations between biosecurity measures, disease experiences (NDV and AI), wild bird contact, gender, and farm size among farmers, using Pearson's Chi-Square tests. Significant differences in cleaning frequency were found (χ^2= 12.0574, p = 0.034), with females cleaning more regularly than males, aligning with Waithanji *et al.* [28]. No significant gender differences in biosecurity adoption were found, consistent with Mensah-Bonsu *et al.* [29]. Farmers with NDV experience were more likely to implement biosecurity measures (χ^2= 4.8624, p = 0.027), as seen in Nigeria and Ghana [30,31]. Avian influenza experience did not significantly influence biosecurity practices (χ^2= 0.8417, p = 0.656), unlike in Egypt [32], likely due to regional differences. The link between AI experience and wild bird contact (χ^2= 67.5817, p < 0.001) highlights wild birds' role in HPAI transmission, aligning with Kalonda *et al.* [33] and emphasizing the need for collaboration along avian migration routes [34]. These findings underscore the importance of tailored biosecurity education and intervention programs.

Limitations of the study: the study relied on self-reported data, which may introduce biases and inaccuracies, potentially affecting the reliability of the data on biosecurity practices, disease experiences, and farm sizes. Furthermore, the study did not explore the socio-economic factors that influence farming practices in detail, which could have provided valuable insights into the dynamics of poultry farming and disease transmission.

Conclusion

This study underscores the urgent need for improved biosecurity and disease management among indigenous chicken and guinea fowl farmers in Northern Benin. Farmers with prior experience of Newcastle disease are more likely to adopt biosecurity measures, while Avian Influenza experience has less impact, likely due to regional differences in disease prevalence. Gender disparities were found, with female farmers managing smaller farms highlighting the need for targeted support like training, microfinancing, and cooperatives. The relationship between AI experience and wild bird contact emphasizes the importance of managing these interactions to prevent AI transmission, calling for vigilance and collaboration along avian migration routes. The study recommends accessible biosecurity training, especially for illiterate and female farmers, as well as strengthening veterinary services, regular health checks, timely vaccinations, and effective outbreak responses. Collaboration between governmental and non-governmental organizations is essential for these measures. Future research should focus on monitoring the impact of interventions and exploring socio-economic factors affecting farming practices to improve poultry health, productivity, and farmer livelihoods in Northern Benin.

What is known about this topic

- *Gender disparities: women in rural areas often dominate small-scale poultry farming, managing smaller operations with fewer resources compared to men who typically handle larger-scale farms;*
- *Disease vulnerability: traditional poultry farms, especially those managed by women, are particularly vulnerable to diseases such as Newcastle Disease (ND) and Avian Influenza (AI) due to limited access to biosecurity resources and knowledge;*
- *Biosecurity practices: the implementation of biosecurity measures is crucial for disease prevention, yet many smallholder farms, particularly those managed by women, often lack proper biosecurity practices.*

What this study adds

- *Gender-specific findings: the study highlights significant gender disparities in farm size and biosecurity practices, with female farmers managing predominantly small-scale farms;*
- *Disease incidence and practices: there is a significant relationship between biosecurity implementation and ND incidence, indicating that farms with prior ND outbreaks are more likely to adopt biosecurity measures; however, AI experience does not significantly influence biosecurity practices;*
- *Recommendations for improvement: the study suggests targeted training programs, microfinancing, and cooperative support for female farmers to enhance their capacity to implement effective biosecurity measures, alongside strengthening veterinary services and vaccination campaigns.*

Competing interests

The authors declare no competing interests.

Authors' contributions

Edmond Onidje, Vitus Burimuah, Oluwole Oyetunde Oni, and Benjamin Obukowho Emikpe participated in the development of the research concept. Edmond Onidje gathered data, conducted data analysis, and drafted the manuscript. All authors have thoroughly reviewed the manuscript and have made equal contributions to its substance. They equally read and approved the final version of the article.

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Tables and figure

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Table 2: distribution of poultry farm size with gender

Table 3: biosecurity and management practices of poultry and guinea fowl farmers in the Northern Region of Benin

Table 4: knowledge and occurrence of Newcastle disease and Avian Influenza in poultry and guinea fowl farms in northern region of Benin

Table 5: the associations between various farm biosecurity practices and diseases frequency

Figure 1: map of the study area

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Table 1: demographic representation of indigenous poultry and Guinea fowl farmers in the Northern Region of Benin		
Demographic	Frequencies	Percentage
Gender		
Female	66	55.93
Male	52	44.07
Age		
<19	2	1.69
20-30	29	24.58
30-50	73	61.86
>51	14	11.86
Level of education		
Illiterate	45	38.14
Primary	53	44.92
Secondary	20	16.95
Employment		
Unemployed	56	47.46
Employed	17	14.41
Self-employed	39	33.05
Retired	6	5.08

Table 2: distribution of poultry farm size with gender				
Farm size	**Gender**		**Chi-Square Value**	**p-value**
	Female	**Male**		
Small-scale (< 50)	40 (60.10%)	15 (28.85%)	16.2020	0.000
Medium-scale (51-200)	23 (34.85%)	24 (46.15%)		
Large-scale (> 200)	03 (04.55%)	13 (25.00%)		
Total	66 (100%)	52 (100%)		

Table 3: biosecurity and management practices of poultry and guinea fowl farmers in Northern Region of Benin

Practices	Frequencies	Percentage
Implementation of biosecurity measures		
Yes	51	43.22
No	67	56.78
Cleaning and disinfection of poultry houses		
Weekly	09	7.63
Every two weeks	28	23.73
Monthly	29	24.58
At the end of each production cycle	01	0.85
Regularly, especially after the harmattan season As needed, depending on the level of cleanliness	06 45	5.08 38.14
Manure management		
Composting	2	1.69
Selling	40	33.90
Spreading on the field as fertilizer	47	39.83
Throw	29	24.58
Quarantine practice		
Yes	36	59.09
No	52	40.91
Isolation of sick bird		
Yes	54	46.15
No	63	53.85
Carcass disposal		
Burial	32	27.12
Incineration	01	0.85
Open disposal	47	39.83
Eat	14	11.86
Giving to dogs	24	20.34
Contact with wild bird		
Yes	36	30.51
No	82	69.49

Table 4: knowledge and occurrence of Newcastle disease and Avian Influenza in poultry and guinea fowl farms in the northern region of Benin		
Variable pair	**Frequencies**	**Percentage**
Farms have experienced newcastle disease		
Yes	58	49.15
No	60	50.85
Common NDV recognition symptoms		
Greenish diarrhea	22	37.93
Respiratory distress and difficulty breathing	09	15.52
Drop in egg production	02	3.45
Torticollis	25	43.10
NDV vaccination		
Yes	61	51.69
No	57	48.31
Farms has experienced Avian Influenza		
Yes	36	30.76
No	81	69.23
Common Avian Influenza symptoms		
Coughing and sneezing	06	17.14
Diarrhea	06	17.14
Respiratory distress and difficulty breathing	2	5.71
Sudden death	09	25.71
Hemorrhagic comb, wattles, and legs	12	34.29
Avian Influenza vaccination		
Yes	00	00
No	118	100
NDV: Newcastle disease		

Table 5: the associations between various farm biosecurity practices and diseases frequency				
Variable pair	**Chi-Square Value**	**Degrees of Freedom (df)**	**p-value**	**Significance**
Gender and biosecurity. implementation	18.610	1	0.461	NS
Gender and cleaning	12.0574	5	0.034	*
Biosecurity implementation and NDV experience	4.8624	1	0.027	*
Biosecurity implementation and AI experience	0.0154	1	0.901	NS
Wild bird contact and ND experience	0.8498	1	0.357	NS
wild bird contact and AI experience	67.4475	1	0.000	*
Outside birds purchase and NDV experience	2.6975	1	0.101	NS
Outside birds purchase and AI experience	0.1784	1	0.673	NS
Quarantine practice and ND experience	0.0000	1	1.000	NS
Quarantine practice and AI experience	7.6765	1	0.006	*
NS- Non significant at p-value < 0.05; *- Significant at p-value < 0.05; ND: Newcastle Disease AI: Avian Influenza				

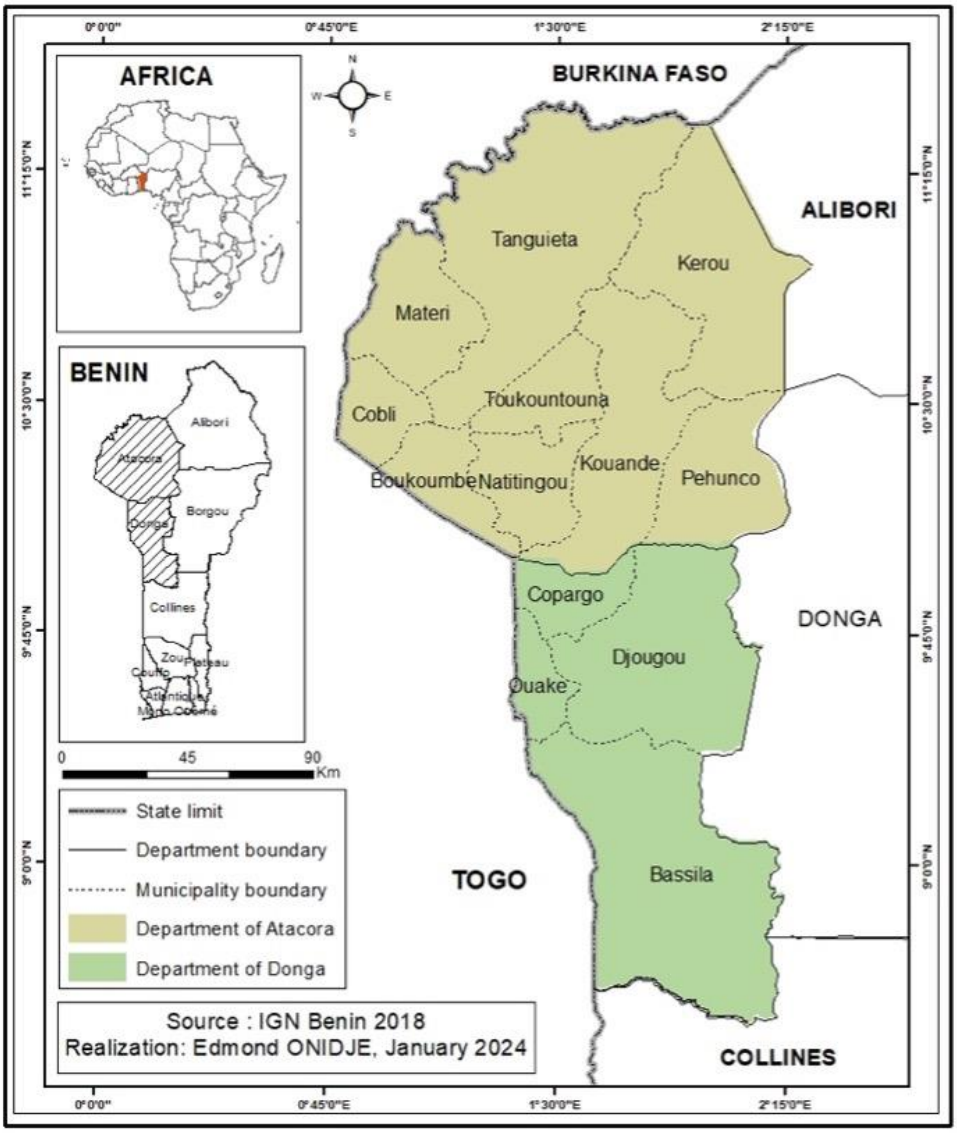

Figure 1: map of the study area