

UNIVERSITY FOR DEVELOPMENT STUDIES
INSTITUTE FOR INTERDISCIPLINARY RESEARCH

17TH ANNUAL INTERDISCIPLINARY CONFERENCE (AIC) 2024



CONFERENCE PROCEEDINGS



THEME:
GLOBALISATION AND LOCAL ECONOMIC TRANSFORMATION:
THE ROLE OF INTERDISCIPLINARY RESEARCH



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17th AIC Proceedings, September 2024

**UNIVERSITY FOR DEVELOPMENT STUDIES
INSTITUTE FOR INTERDISCIPLINARY RESEARCH
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SEPTEMBER 2024

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IIR AT A GLANCE

The Institute for Interdisciplinary Research (IIR) of the University for Development Studies (UDS) is a leading provider of multidisciplinary research and consultancy services to local, national and international organisations operating in the public and private sectors. The Institute conducts research and provides consultancy services on a wide range of fields including agriculture, architecture, climate change, clinical trials and medicine, engineering, development, ICT, strategic planning, governance, management and business, among others. One of the core competencies of IIR is its interdisciplinary team of researchers and consultants with many years of impeccable industry experience.

MANDATE: IIR exists to coordinate and facilitate research and grantsmanship in the university. Specifically, the University Statutes (Statute 51.4) mandate it to:

- Engage in research on topical national development issues.
- Organise Annual Harmattan School Lecture Series for policy review and brainstorming sessions on development issues that affect Northern Ghana in particular and Ghana as a whole.
- Organise Annual Interdisciplinary Conference (AIC) for the presentation and peer review of research work leading to publications.
- May run undergraduate and graduate academic programmes.
- Forge collaboration with Development partners.

VISION: The Institute is envisioned “to be a leading Interdisciplinary Research Institute, proffering multidisciplinary solutions to contemporary development challenges”.

MISSION: The mission is “to conduct cutting-edge interdisciplinary research that provides multidisciplinary solutions to contemporary national and global development challenges through:

- Formation of interdisciplinary teams and expert panels for research and innovation;
- Building of strategic national and international partnerships for interdisciplinary research and innovation for development impact;
- Mobilisation of funding from internal and external sources for interdisciplinary research and innovation;
- Creation of academic-industry-policy linkages to stimulate co-design, planning and implementation of interdisciplinary research projects that provide multidisciplinary solutions to contemporary development challenges;
- Dissemination of interdisciplinary research outputs to key stakeholders, especially policymakers, practitioners, and industry players;
- Advocacy for evidence-based decision making using interdisciplinary research outcomes and solutions”.

CORE VALUES:

- **Excellence** - Providing the most efficient, effective, reliable and sustainable multidisciplinary solutions to national and global development problems;
- **Inclusiveness** - Ensuring all sectors of society are involved in finding solutions to our common challenges;
- **Sustainability** - Ensuring the Institute continues to conduct interdisciplinary research in the short-, medium- to long-term;
- **Teamwork** - Working together for a common development impact; and
- **Responsiveness** - Providing tailored solutions to societal problems.

ABOUT THE ANNUAL INTERDISCIPLINARY CONFERENCE (AIC)

The Annual Interdisciplinary Conference first started as a platform for lecturers and researchers in the university to come together to share their research outputs so as to promote peer learning and scholarship. It was christened Interfaculty Lectures (IFL) at the time. The first IFL was held in 2007 on the then Navrongo Campus of the UDS. To broaden the scope in response to increasing demand, the name was changed to Annual Interdisciplinary Conference (AIC). The AIC has grown over the years beyond the UDS and Ghana to attract participants from across Ghana and the globe. The Conference offers seasoned, mid-career and early-career researchers the opportunity to share their research findings for feedback. The 2024 AIC was under the theme, “**Globalisation and Local Economic Transformation: The Role of Interdisciplinary Research**”. The sub-themes were:

- Interdisciplinary Research for Innovations in Basic and Applied Sciences for Local Economic Transformation;
- Interdisciplinary Research for Multidisciplinary Solutions in Social Sciences and Humanities for Local Economic Transformation; and
- Interdisciplinary Research for One Health in Medical and Health Sciences for Local Economic Transformation.

Overall, fifty-eight (58) presentations from researchers across the country were submitted. This represents an increase over last year, when forty (40) abstracts were presented. In terms of the thematic areas, ten (10) abstracts were accepted from Social Sciences and Humanities for presentation, twenty-four (24) from Medical and Health Sciences and twenty-four (24) from Basic and Applied Sciences.

A MESSAGE FROM THE DIRECTOR OF IIR

It is with great pleasure that I welcome you all to this year's Annual Interdisciplinary Conference (AIC 2024). I am extremely humbled to be sharing this message with this academic gathering for the second time since assuming office as Director of the Institute for Interdisciplinary Research (IIR) of the University for Development Studies (UDS) about a year ago. The AIC started seventeen (17) years ago as an internal academic platform for Lecturers across the Faculties of UDS to share their research outputs and ideas. The tireless work of my predecessors (Prof. Jefferson Achiriga of blessed memory, Prof. Ishmail Bin Yahya, Prof. David Millar, Prof. Felix Y. T. Longi, Dr. A. H. K. Abasi of blessed memory, Chief Prof. Stephen B. Kendie, Prof. Seidu Al-hassan, Dr. Edward S. Mahama and Prof. Abubakari Abdulai) laid the foundations and also ensured the transformation of this internal academic platform to an international one. On behalf of my hardworking colleagues (Prof. Joseph Abazaami, Deputy Director; Ms Juliana T. Yirnou, Administrator; Ms Matilda Gyampana, Principal Administrative Assistant; Ms Vida A. Issah, Principal Administrative Assistant; Mr. Mubarik I. Napari, Senior Accounting Assistant; Mr. Umar Diawk, Assistant Transport Officer) at IIR, we wish to express our gratitude to all those who worked so hard and around the clock to sustain and transform IFL to AIC.

The theme for this year's conference, **“Globalization and Local Economic Transformation: The Role of Interdisciplinary Research”**, is not only appropriate but fundamental to the forward march in our post-crises efforts to build a more inclusive and sustainable society for all. For the first time, the Institute is organizing the “Research Week Celebration” under the theme, **“Research for Career Progression, Institutional Visibility and Development Impact”**. The Conference forms part of the week-long celebration of our collective achievements in research. This year, we received about 60 abstracts including submissions from abroad and we are grateful to all researchers and authors who found AIC a credible and preferred outlet to outdoor and share their research outputs with colleagues in the academic community.

We wish to reiterate the commitment of the Institute to promoting research excellence for development impact in our university and beyond. Our commitment is grounded in the UDS Strategic Plan (2017 – 2023) that indicates that the University aims to:

1. Put in place a stable financial system through, among others:
 - a. Introduction of innovative and demand-driven on and off-campus professional and short-term training programmes.
 - b. Kick-starting a grantsmanship programme to develop grant-winning proposals.
 - c. Expansion of consultancy and other services of the university.
 - d. Institution of a mechanism to recognise individuals/groups who have contributed financially to research, teaching and service to the university.
 - e. Attraction of funding through research.
2. Promote improved innovative research for community and national development through, among others:
 - a. Initiation of research projects/programmes to address the problems of rural communities in response to national development needs.
 - b. Promotion of basic, applied and collaborative research with industry, communities and institutions of higher learning and research.

We will continue to create opportunities through our flagship activities to promote dialogue and stakeholder engagements on the socioeconomic transformation of our community, country and beyond. Distinguished Conference Participants, Ladies and Gentlemen, once again, we welcome you to AIC 2024 and wish you all a fruitful and memorable Conference. Thank you!

ABOUT THE IIR RESEARCH WEEK CELEBRATION

The Institute for Interdisciplinary Research (IIR) held its Maiden Research Week Celebration this year, which started on Monday, 9th September, 2024 and ended on Friday, 13th September, 2024. The theme for the Celebration was **“Research for Career Progression, Institutional Visibility and Development Impact”**. The activities for the week comprised:

1. **School/Faculty/Institute/Centre Research Exhibitions** - This event was meant to showcase the works of our Researchers/Lecturers across the Schools, Faculties, Institutes and Centres to the university community and beyond. At the exhibition event, all Deans and Directors were given the opportunity to make brief presentations of research activities in their Schools/Faculties/Institutes/Centres. Thus, we encouraged all Deans and Directors to prepare not exceeding ten (10) slides research activities under them for presentation. The event was held at the Nyankpala Campus on Monday, September 9, 2024, from 8:30 am to 4:30 pm.
2. **Vice Chancellor’s Capacity Building Initiative/Researcher Development Seminar**—This event focused on building the capacities of our Lecturers and researchers in student supervision techniques, writing articles for publication in credible journals, and grantsmanship for personal and institutional growth. It was held at the City Campus on September 10, 2024, from 8:30 a.m. to 4:30 p.m.
3. **Annual Interdisciplinary Conference (AIC)** - This was held from September 11 to 12, 2024, from 8:30 am to 4:30 pm daily. The 2-Day event witnessed approximately fifty-five (55) presentations across disciplines. This was held at the UDS Guesthouse located at the Central, Tamale Campus, Dungen.
4. **UDS Research Awards Ceremony** - The maiden UDS Research Awards Ceremony was held on September 13, 2024, to recognise and

award selected faculty/teams in the University with seed grants to bolster research output and impact. The event was held in the Dr. Andani Andan Academic Board Chamber from 8:30 am to 12:30 pm. Cumulatively, these celebrations were planned and executed with the sole aim of fostering collaboration, creating opportunities for peer learning and showcasing the painstaking efforts we are all making towards research excellence in the university. We thank all those who actively participated in the celebrations and encourage everyone to continue to participate.

ACKNOWLEDGEMENTS

We wish to acknowledge the University Management, particularly the Vice-Chancellor, Prof. Seidu Al-hassan, Pro-Vice-Chancellor, Prof. Elliot Haruna Alhassan, Registrar, Mr. Nurudeen Issah Abubakar, Director of Finance, Dr. Mohammed Hardi Shaibu and others, for the unrelenting support for the Annual Interdisciplinary Conference (AIC). Management continues to provide funding support and encouragement for which we are eternally grateful. To authors who find AIC a credible outlet for their papers, we are grateful to you. To the Staff of IIR, Prof. Joseph Abazaami, Deputy Director; Ms Juliana T. Yirnuo, Administrator; Ms Matilda Gyampana, Principal Administrative Assistant; Ms Vida A. Issah, Principal Administrative Assistant; Mr. Mubarik I. Napari, Senior Accounting Assistant; Mr. Umar Diawk, Assistant Transport Officer and the National Service Personnel, Mr. Abukari Abdulai and Ms Sheila Tei, your enormous contributions and tireless efforts to ensure that the Research Week Celebration and the AIC in particular was a success are highly acknowledged.

PRINCIPAL OFFICERS OF UDS



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**Tee Sheila Tei,
National Service Personnel**

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Aug. 2000 – Jul. 2002



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Sept. 2002 – Aug. 2005



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Sept. 2005 – May 2008



Prof. Felix Y. T. Longi,
April – Sept, 2008



Prof. Stephen B. Kendie,
Oct. 2008 – Jul. 2010



Prof. Seidu Al-hassan,
Aug. 2010 – Nov. 2015



Prof. Edward S. Mahama,
Dec. 2015 – Aug. 2019



Prof. Abdulai Abubakari,
Sept. 2019 – Aug. 2023

**PREVALENCE AND ANTIBIOTIC SUSCEPTIBILITY PATTERN
OF METHICILLIN-RESISTANT *STAPHYLOCOCCUS AUREUS*
FROM GARI SOLD AT THE VARIOUS MARKETS WITHIN
TAMALE METROPOLIS AND TOLON DISTRICT**

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ABSTRACT

Gari, a traditional African food made from cassava, is popular in the West African sub-region. It is known as the students' companion due to its consumption among high school students. However, there is limited data on the microbial safety of Gari in Ghana. *Staphylococcus aureus*, a common flora on human skin, can indicate the hygienic conditions of contact foods. This research aimed to determine the presence of *Staphylococcus aureus* and methicillin-resistant *Staphylococcus aureus* (MRSA) in Gari sold in two Northern Region districts. Eighty (80) Gari samples were aseptically collected from the markets within the Tamale Metropolis and Tolon District. Baird-Parker media supplemented with egg yolk, a selective media for *Staphylococcus aureus*, was used and confirmed biochemically with catalase and coagulase tests. The susceptibility test was conducted using the disk diffusion method following EUCAST guidelines. The results showed that 50% of Gari samples were positive for *Staphylococcus aureus*, with 95% of the 40 isolates being MRSA. *Staphylococcus aureus* isolates were highly resistant to ceftazidime 97.5%, ampicillin 95%, cefoxitin 95%, ceftriaxone 95%, amoxicillin 95%, and tetracycline 35%, while the multi-drug-resistant pattern was 100%. The study reveals a high prevalence of

Staphylococcus aureus in Gari sold in the Tamale metropolis and Tolon District, requiring public education to reduce contamination levels. The high rate of MRSA is a cause for concern and further investigation is needed. Public education is to be required in the handling of Gari.

KEYWORDS: Gari, *Staphylococcus aureus*, Antibiotics

INTRODUCTION

White gari is the staple meal in Northern Ghana, mostly in Tamale Metropolis and Tolon District. It is produced by fermentation and gelatinization of fresh cassava tubers that have been fermented and gelatinized are used to make gari, a creamy-white, granular flour with a faintly fermented flavor and a faintly sour taste (Amgbeye *et al.*, 2021). Typically, people either eat gari dry or soak it in cold water with sugar, roasted groundnuts, and fish as complements (Susan, 2021), and it has a shelf life of six months when kept in proper storage (Adinsi *et al.*, 2019). According to an earlier study, Gari is recognized to have significant levels of antioxidants and could eliminate harmful microorganisms through the fermentation process (Nwaliowe *et al.*, 2023). However, gari may be contaminated as a result of packaging, handling, inadequate sterilization, transportation, and storage. The quality of gari is influenced by many factors, including processing, transportation, and storage (Teeken *et al.*, 2021). According to Mulade (2015), gari is a social, economic, and geographic preference, but there is little knowledge regarding the potential health risks that could arise from improper production and packaging, handling, inadequate sterilization, and storage of gari. Gari has been discovered to be processed in a typically unclean manner, which poses a major risk to the health and environment of the final consumers (Zahraoui *et al.*, 2023). However, there has not been much work done on gari to isolate organisms with pathogenic potential that endanger consumers' health (Xiang *et al.*, 2019).

One major global health problem is food-borne diseases and the increasing dominance of multi-drug resistance to Methicillin-resistant *Staphylococcus aureus* (MRSA). Generally, the limited therapeutic techniques for MRSA-associated infections have contributed greatly to

acquiring food-borne diseases, leading to great economic and human losses (Money, 2014). In general, *S. aureus* has occurred as a coagulase-positive bacterium responsible for Healthcare-Acquired *Staphylococcus aureus* (HA-*S. aureus*), Community Associated (CA-*S. aureus*), and livestock-acquired infections threatening so many lives (Engelbrecht *et al.*, 2022). *S. aureus* are commensal and opportunistic due to its invasiveness, resistance to antibiotics, as well as the ability to produce one type of virulence factor called *Staphylococcus* enterotoxins, responsible for causing *Staphylococcal* food poison (Parija, 2023; Martínez-Seijas *et al.*, 2023). An investigation of microbial contamination in ready-to-eat foods submitted *Staphylococcus aureus* as the most common pathogen (Budiarso *et al.*, 2023). There are so many concerns when there is the presence of *Staphylococcus aureus* contamination in food (Deddefo *et al.*, 2023). Many investigations reported that producers of food are the cause of contamination by *Staphylococcus aureus* in many food products (Ahmed *et al.*, 2023). According to one school of thought, cross-contamination from other sources at the place of food preparation is a significant source of *Staphylococcus aureus* transmission (Karthikeyan *et al.*, 2023). Notably, good hygiene practices in food production, such as clean water usage and hand and equipment washing with detergents, which is a common and inexpensive practice of avoiding *Staphylococcal* food-borne disease, are mostly ignored by food producers, sellers, and consumers as well. A study has also attributed it to the fact that inappropriate washing of equipment used in the preparation of food products, as well as poor storage facilities and contaminated environments, are major causes of *Staphylococcus aureus* contamination (Deddefo *et al.*, 2023). Also, research shows that food products that require more handling and manipulations during preparation and processing are more likely to harbor *Staphylococcus aureus* contamination (Kannan *et al.*, 2021). Most often, the equipment that is used in the gari products is not well-cleaned nor washed (Deddefo *et al.*, 2023). The millers used equipment and pistils, with few being washed with sponges and detergents, whilst others with only water (Holmstrom, 2023).

Moreover, most of the producers worked in an environment that is not safe (a dirty environment) for gari production (Nimoh *et al.*, 2023). Also, the mean microbial count of *Staphylococcus aureus* was recorded as highest in gari sold at some markets in Nigeria (Adetunji *et al.*, 2017). Bacteria resistant to different effective antibiotics are now a global issue (Costanzo *et al.*, 2023). MRSA is one of the public health concerns and is often referred to as a deadly pathogen in hospital multidrug resistance microorganisms (Vivas *et al.*, 2019). Another stimulating characteristic of this opportunistic pathogen is that they are even viable and stable at heating (60 °C for 16 hours) and freezing (Kadariya *et al.*, 2014).

This research is to assess the prevalence of *staphylococcus aureus* and MRSA in gari sold on various markets in Tamale Metropolis, to determine the antibiotic-resistant pattern of the isolated *Staphylococcus aureus*, to determine the rate of MRSA among the isolated *Staphylococcus aureus*, and to determine the multidrug-resistant pattern of MRSA.

MATERIALS AND METHODS

Study Area, Sampling, and Design

This study was conducted in the Tamale metropolis. Tamale metropolis is the capital city of the Northern region of Ghana. Gari samples were randomly taken from three main markets (Central market, Aboabo market, and Lamashegu market) and supermarkets in the Tamale metropolis. The metropolis lies between the latitudes 9 °16 and 9 °34 North and longitudes 0 °36 and 0 °57 West. Tamale has an annual rainfall pattern of 1100 mm and a mean temperature range of 28°C and 43°C (Ghana Statistical Service, 2014). The bacteriological analysis took place in the Spanish Laboratory Complex, specifically in the One Health laboratory of the University for Development Studies. A total of 80 gari samples were randomly taken from three main markets (Central Market, Aboabo Market, and Lamashegu Market) and supermarkets in the Tamale metropolis. Samples were collected using sterile bags and were kept in an ice chest containing ice cubes, and were transported to the Spanish Laboratory complex for bacteriological analysis.

The bacteria were isolated using five different types of media that were prepared according to the manufacturer's protocol. The media are: Baird Parker, nutrient agar, Brain Heart Infusion and European Bacteriological Agar, peptone water, and Mueller-Hinton agar. A saline solution was also prepared for performing antibiotic susceptibility tests. All media and buffers that were used were autoclaved at 121 °C for 15 minutes.

After sample collection, 25 g of each gari sample was weighed using an analytical balance into sterile bags and labelled accordingly. 250 ml of prepared peptone water was measured and poured into each sterile bag containing 25 g of gari samples, and was shaken gently for homogenization. Each sample was aseptically spread on the Baird Parker media supplemented with egg yolk using a sterilized cotton swap. It was then kept in an incubator at a temperature of 37 °C for 24-48 hours.

After incubation, *Staphylococcus aureus* was identified based on its morphological characteristics on the Baird-Parker medium. The formation of a greyish-dark colour is an identification of the presence of *Staphylococcus aureus*. The greyish colour forms a ring around the dark colour.

Confirmation of Staphylococcus Aureus

Catalase test

The method of catalase test employed was the slide or drop method. This was done by smearing a loopful of the bacteria from a well-isolated colony (pure culture) onto the microscope slide. A drop of hydrogen perox (H₂O₂) was then placed (two drops) onto the organism and was observed for immediate bubble formation. If bubbles are produced, then the bacteria

are positive catalase, but if there are no bubbles, then the bacteria are negative catalase.

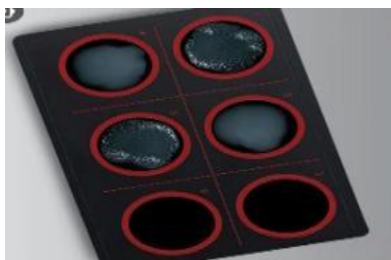


Plate1: Coagulase test

Antibiotic susceptibility test

This was done according to the Kirby-Bauer disk diffusion method. The lamina flow hood was disinfected with 70 % alcohol. With the help of a 10 mL calibrated pipette, 2 mL of the saline solution was pipetted into sterilized glass test tubes and labelled according to the number of each *Staphylococcus aureus* isolate. Using a sterilized metallic loop, each *S. aureus* isolate was scooped from the nutrient agar and aseptically dissolved against the walls of the glass before using a multi-purpose vortex to completely dissolve until bacterial suspension was achieved. The suspension was then compared to 0.5 McFarland turbidity standard using the McFarland densitometer. Sterile cotton swabs were dipped in each of the suspensions and aseptically spread on the surface of the Mueller-Hinton agar plates.

After waiting for about 5 minutes to allow the Mueller Hinton agar plates to settle, six different antibiotic discs, such as Tetracycline (TET 30 µg), Ampicillin (AMP 10 µg), and Cefoxitin (FOX 30 µg), amoxicillin-clavulanic acid (30 µg), ceftazidime (30 µg), and ceftriaxone (30 µg), were aseptically placed onto each of the plates labelled according to the *S. aureus* isolates. All the Mueller Hinton plates containing the six different antibiotics were then incubated at 37 °C for 18- 24 hours. After 24 hours, the zone of inhibition diameter (mm) cleared by the antibiotics was measured with a ruler and compared with the EUCAST clinical breakpoint

(2020). Results were interpreted as resistant and susceptible according to the EUCAST breakpoint (2020).



Plate 2: Antibiotic susceptibility test results



Plate 3: Identification and isolation of Staphylococcus aureus on Baird-Parker media

Data Analysis

Data on antibiotics were entered into Excel and analyzed using IBM Statistical Package for the Social Sciences (SPSS) statistics version 20. The significant difference ($p < 0.05$) was determined between the sample locations in terms of the prevalence of the antibiotic-resistant level for the isolated *Staphylococcus aureus*, and Methicillin *Staphylococcus aureus* was determined using the person's square chi-square test.

RESULTS

Prevalence of *Staphylococcus aureus* Based on Sample Location

After bacteriological analysis, 40 (50%) of the 80 total samples were confirmed to be positive for coagulase *Staphylococcus aureus*. 9 (22.5%) were isolated from the Aboabo market, 10 (25%) were isolated from the Central Market, 12 (30%) were isolated from the Lamashegu market, 7 (17.5%) were isolated from Nyankpala and 2 (5%) were isolated from supermarkets (Figure 1).

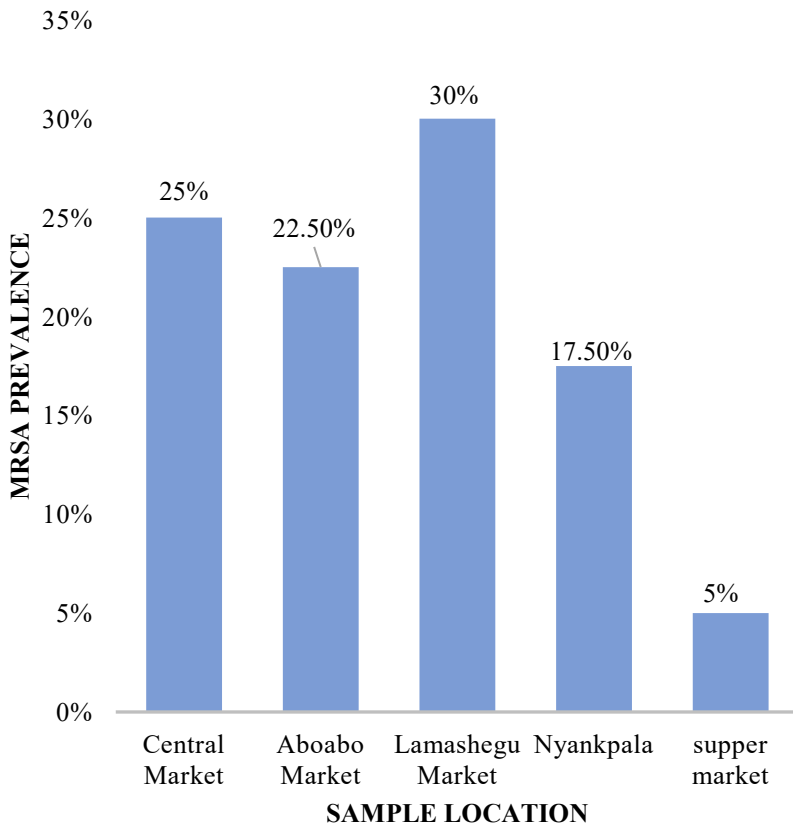


Figure 1: Prevalence of *Staphylococcus aureus* based on sample location

Prevalence of *Staphylococcus aureus* Based on Display of Gari at the Market

The samples were also partitioned according to how gari was exposed at the market (open bowl, tied in rubbers, and packaged). For the open bowl, 24 (60%) were positive *S. aureus* isolates. Also, for the gari tied in rubbers, 14 (35%) were positive *S. aureus* packaged gari samples recorded 2 (5%) for *S. aureus* isolates (figure 3).

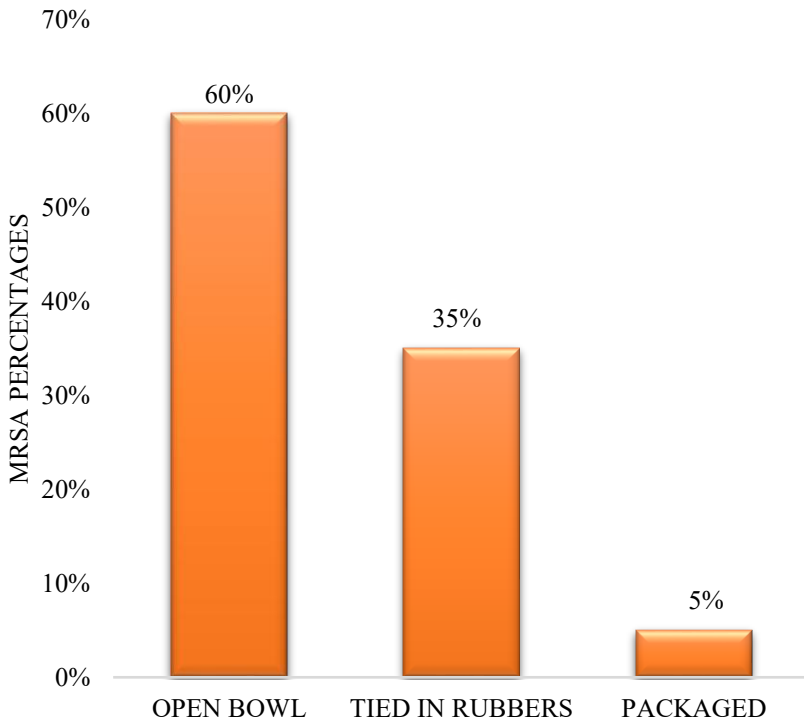


Figure 3: Prevalence of *Staphylococcus aureus* based on how gari was displayed at the market

Antibiotic susceptibility of *Staphylococcus aureus*

Out of the total of 40 *Staphylococcus aureus* isolates, 38 (95%) were resistant to amoxicillin-clavulanic acid, ampicillin, cefoxitin, and ceftriaxone whilst only 2 (5%) were susceptible to these antibiotics. In addition, 14 (35%) were resistant to tetracycline and 26 (65%) susceptible while 39 (97.5%) were resistant to ceftazidime and 1 (2.5%) susceptible. (figure 4)

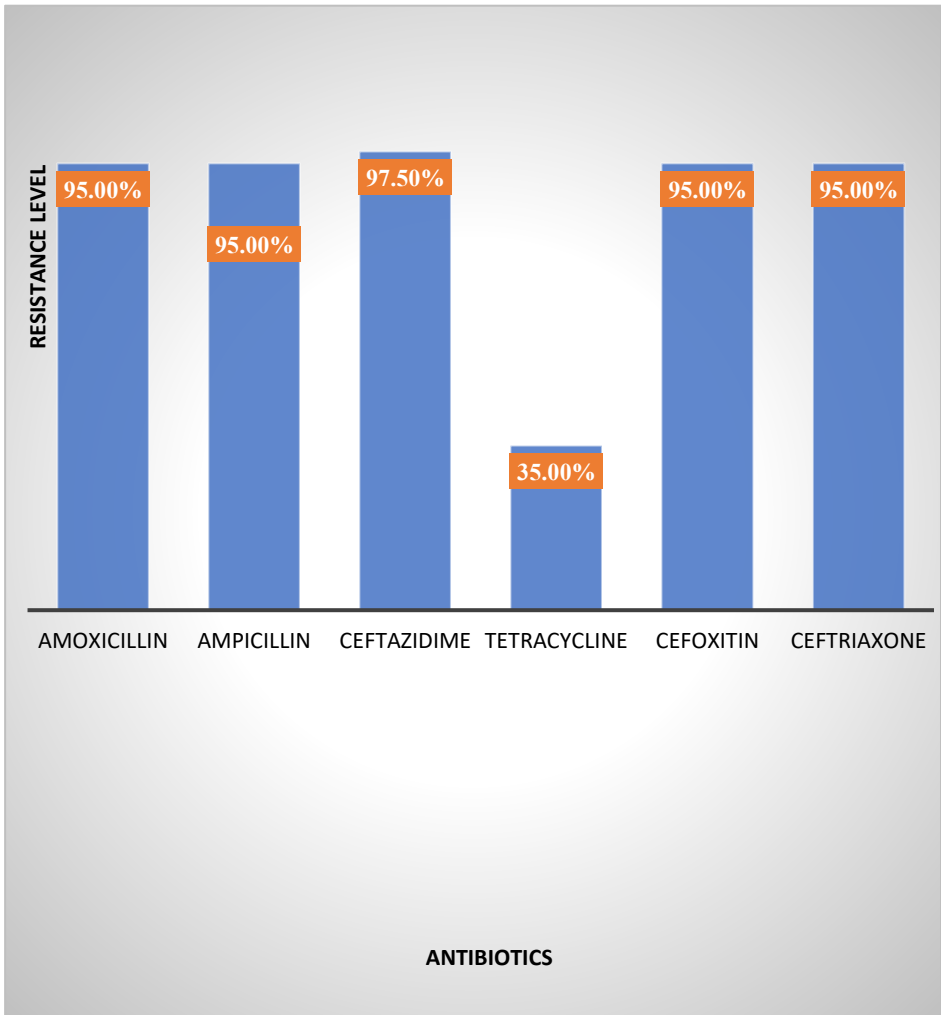


Figure 4: Antibiotic susceptibility test results

Multi-drug-resistant pattern of *S. aureus*

All the *S. aureus* strains were multi-drug resistant. Those that were resistant to two classes of antibiotics were 27 (67.5%) and 13 (32.5%) were also resistant to three classes of antibiotics (figure 5).

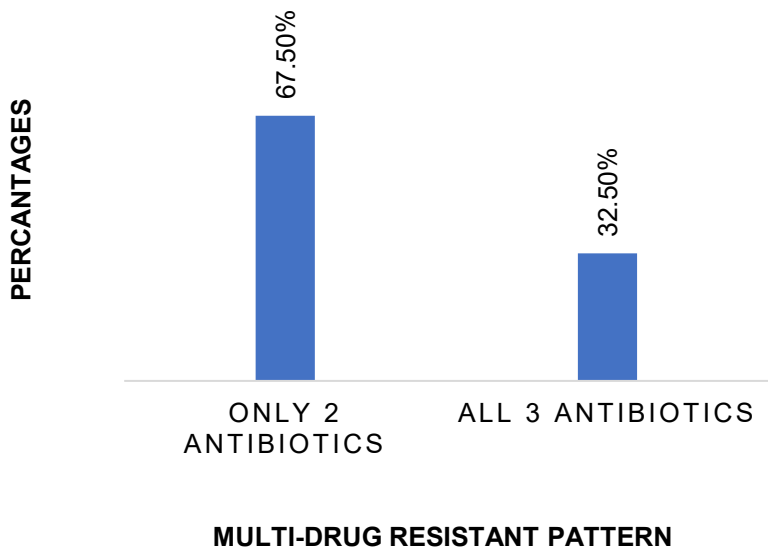


Figure 5: Multi-drug-resistant pattern of *Staphylococcus aureus*

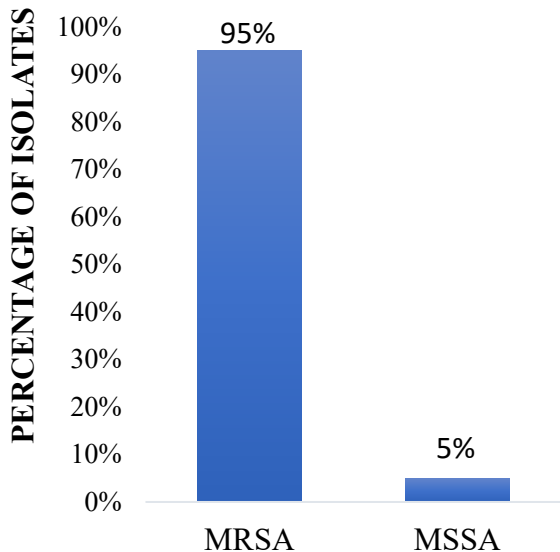


Figure 6: Distribution of MRSA And MSSA Isolates

DISCUSSION

A total of 80 gari samples were collected from the various markets within Tamale metropolis and Tolon District. After bacteriological analysis, 40 samples representing 50% showed positive for *Staphylococcus aureus* of the 80 gari samples. This result is in agreement with similar research done in Nigeria, where there was a 44.7% prevalence of *Staphylococcus* spp (*Staphylococcus epidermidis* and *Staphylococcus aureus*) in gari (Akharaiyi & Obem, 2019). These organisms might have gotten into the gari through the sellers since they are mostly found on the hands, noses, throats, and clothing of the sellers.

The distribution of the prevalence of *Staphylococcus aureus* varied from the market. This agreed with the work of Egbuobi *et al.* (2015) in Nigeria, which indicated that the variation in the distribution of *S. aureus* was due to the practices of the food vendors and environmental conditions.

Lamashegu market recorded a high prevalence of *Staphylococcus aureus* (30%). This may be a result of a dirty environment in the marketplace. The gari samples from this particular market were very dirty. Rubbish is often dumped around these markets. This is in line with research done by Xiang *et al.* (2022), who listed their sources of food contamination among other factors such as waste products and dust within the environment. Followed by Nyankpala with a prevalence of 17.5% and the Central Market, which showed a prevalence of 25%. Also, the Aboabo market recorded a 22.5% prevalence of *S. aureus*. The environmental condition of Central and Aboabo markets is cleaner than Lamaegu market, even though the market is smaller than Central and Aboabo. The gari sold at these two markets was cleaner as compared to that of the Lamashegu market and Nyankpala. Refuse disposal is more properly managed in these markets than Lamashegu market. Sellers and aerosols could be the major source of contamination in these markets because most of the sellers were using their bare hands in serving. This confirmed the work of Somda *et al.* (2018), who said that the vendors can be the source of pathogens such as *Campylobacter*, *E. coli*, *Shigella*, *Salmonella*, and *S. aureus*, which can transfer these foods-borne pathogens to consumers.

The 5% prevalence recorded against the well-packaged gari can be a result of an unskilled habit of the gari producers who contaminated the products, mostly during the cooling and packaging stage of their production. This corroborates the reports of Kshetri, (2021), who said that foodborne infection could have been minimized if the food producers and processors were taught and trained in proper food handling, and consumers were advised to be careful of their choice of food. Considering how gari is exposed to the environment, from the results, the number of positive isolates from the well-packaged gari, gari tied in rubbers, and open gari was 5%, 35%, and 60%, respectively. This means that gari that were in the open environment were more contaminated with *S. aureus*. This could be a result of environmental factors such as flies that can be carriers of *S. aureus* and other pathogens (Sobur *et al.*, 2022). There could also be a result of cross-contamination from the sellers, the containers used in serving, animal traffic, or from one seller to another. Moreover, microbes floating in the air can also be a source of contamination of pathogenic organisms, and if Gari is kept in such an environment, it will be contaminated. Concerning the antimicrobial susceptibility test, *Staphylococcus aureus* isolates were confirmed highly resistant to ceftazidime 97.5%, ampicillin 95%, cefoxitin 95%, ceftriaxone 95%, amoxicillin 95% and tetracycline 35%.

The high prevalence of *S. aureus* resistance can be supported by a similar study to check the prevalence of MRSA in fufu grinding machines in the Tamale metropolis (Salim, 2018). It is also in line with the isolates of *Staphylococcus aureus* against Cefoxitin (80%) used to determine the Methicillin-resistant rate in diverse water springs with higher multidrug-resistant (30.7%) against gentamicin, ampicillin, ceftazidime, amoxicillin, cefuroxime, and ofloxacin (Albadri, 2021). It could also be realized that 26 (65%) isolates of *S. aureus* were highly susceptible to tetracycline, but on the other hand, they also appeared as highly resistant to ampicillin, cefoxitin, ceftriaxone, ceftazidime, and amoxicillin. This result agrees with a study reported in China where *S. aureus* isolates were 97.6% resistant to penicillin, cefoxitin, ampicillin, and erythromycin in fresh

fruits vegetables, and other ready-to-eat foods (Wang *et al.*, 2017). This high level of resistance to the antimicrobial agents by *S. aureus* in this research could be due to their wide use for the treatment of human-animal MRSA infections.

All the *S. aureus* isolates were multi-drug resistant, representing 100%. This is in line with research from South Africa that reveals a high MRSA prevalence from blood cultures, of which about 80% were multi-drug resistant (Costa *et al.*, 2022).

This result of high multidrug-resistant resistance (100%) can also be compared to similar work done by Shamsuddeen, (2017). This could probably be because the isolates were observed in all different gari sold at the markets involving human contact and other poor hygienic conditions, and so the isolates have developed more phenotypic features to survive in the different environments.

CONCLUSION

The study reveals a high prevalence of *Staphylococcus aureus* in Gari sold in the Tamale metropolis and Tolon District, requiring public education to reduce contamination levels. The high rate of MRSA is a cause for concern, and further investigation is needed. Public education is required on the handling of Gari. The high rate of MRSA in this research indicates that antimicrobial agents used against *S. aureus* infections are not as highly effective treatment doses as we imagined anymore. From the research, 40 (50%) out of the 80 total gari samples were positive for *Staphylococcus aureus* isolates. Most of the *Staphylococcus aureus* isolates were isolated from the open gari (60%) sold at markets, and 35% and 5% of *Staphylococcus aureus* were isolated from gari that were tied in rubber and gari that were well packaged, respectively. These were attributed to poor hygienic conditions. There was a high prevalence of MRSA (95%) in gari sold at the various markets, and they were all multidrug-resistant. This high prevalence needs to be addressed through public education to reduce the level of contamination.

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STATIC AND DYNAMIC ANALYSIS OF MOTORIZED TRICYCLE CHASSIS IN GHANA

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ABSTRACT

Motorized tricycles serve as a means of transportation in Ghana and thus contribute to the economic growth of the country. These motorized tricycles have design specifications. However, because of the high demand for transportation, it has been observed that many tend to overload them, resulting in ride discomfort, ride safety, and stability problems. Dynamic analysis of a motorized tricycle chassis was performed to evaluate the dynamic characteristics (that is, natural frequencies, mode shape, and total deformation) of the chassis under the action of varying loads. Secondary data was obtained from the 200ZH-E tricycle manual. Measurement of the chassis parts was also carried out. Data was collected from 20 motor king operators on how they load their machines with goods. The average varying loads were obtained to be 943.5 kg, 1155 kg, 1160 kg, 1240 kg, and 1282.5 kg. The chassis was modeled using ANSYS software, and dynamic analysis was performed by applying various loads. The 200ZH-E motorized tricycle chassis was designed to carry a maximum load of 500 kg, as specified in its design. The maximum natural frequency for the varying loads was 222.86 Hz. Deformation increased with increasing load.

Keywords: Motorized tricycle, chassis, ANSYS software, dynamic analysis, finite element analysis, modal analysis, harmonic response analysis, transient structural analysis

INTRODUCTION

Transportation is regarded as a major issue in the socio-economic growth of any nation (Oduro 2012, Healey and Ilbery 1990). Transportation in

whichever way enables people to access goods and services, and facilities across national boundaries. There is a very strong connection between economic growth and transportation (Rodrigue 2017, Gillen 1996). The use of motorcycles for public transportation is not entirely a new phenomenon in African countries such as Nigeria. It started sometime in the mid-1970s, and its widespread utilization for this aim is increasing and is worsened by the high rate of unemployment and thus, many unemployed graduates are getting into the commercial motorcycle business, popularly called Okada (Adesanya 1998). In nearly every major city in Africa (Ghana inclusive), the main mode of public transport is the use of buses (African Public Transport Association, 2010). However, due to high demand for transportation, the motorized tricycle was introduced to complement the commercial transport system (Buses). Motorized tricycles have taken over the transportation industry in Northern Ghana (Ghana News Agency, 2017). In the villages, market people utilize motorized tricycles as a mode of transportation. They are also used to transport market items and farm produce from one location to another. All these functions can be performed by motorized tricycles if and only if their skeletal components are in good working order. The chassis is the skeleton of a motorized tricycle. The chassis of a motorized tricycle is the structural component that offers passenger safety and a sturdy platform for installing the engine, transmission, and suspension components (Okpala et al. 2017). This motorized tricycle has a design specification such that the maximum load that it can carry so that it doesn't fail over a short period is 500 kg (Electronic Engine Control Manual). However, due to the great demand for transportation, several people have been observed to overload them. As a result, there is a gap between the design of motorized tricycles and ride comfort, which is the problem under investigation. These difficulties can sometimes result in accidents that cause death or destruction of property. To help improve the design safety of motorized tricycle chassis, static and dynamic properties were researched. Many researchers have used different FEA tools to perform dynamic analysis on automotive chassis over the years to help establish dynamic characteristics such as

mode shapes, natural frequencies, and total deformation, as well as to assess the influence of varying loads. To help fill the gap between the design and ride comfort of the tricycle, static and dynamic analyses were carried out to determine the impact of such dynamic loadings on the dynamic properties (natural frequencies, mode shape, and total deformation) and strength of the chassis. This will offer the necessary data for physical chassis manufacture and subsequent research.

Vasek and his collaborators (Vasek et al. 1998) conducted a dynamic analysis of a truck. They vibrationally evaluated the truck in addition to simulating it with finite element software (ANSYS) and ensuring that the structure's vibrational modes are in the right range. Agrawal (2015) conducted research to generate results to resolve challenges associated with structures of a commercial vehicle, such as strength, stiffness, and fatigue characteristics, along with stress, bending moment, and vibrations. This was made possible by static and dynamic analysis, putting together existing theoretical knowledge and advanced analytical methods. Design of a Chassis was carried out by utilizing CATIA, and finite element analysis was also carried out by utilizing ANSYS. The natural frequencies of a ladder chassis with finite elements were compared by Zhang and Tang (1998). Guo et al. (2008) investigated the dynamic and modal analysis of a space chassis (complex 3-dimensional chassis) and used the principle of superposition to examine the transient response. Reddy and Reddy (2014) looked at using FEM to model and analyze container chassis to increase load carrying capacity and reduce chassis failure due to bending by adding stiffeners. The rectangular stiffeners were installed between the cross members and bolted to the chassis. The ANSYS-14 study findings reveal that there is a 37.11 percent reduction in Von Mises Stress in chassis with a stiffener compared to no stiffener, while stress is reduced. A TATA 407 truck chassis was statically and modally analyzed by Nalawade et al. (2014). CATIA was used for the modeling, and ANSYS Workbench was used for the finite element analysis. The results of the analysis on the ladder frame with structural steel and E-Glass composite showed that the maximum shear stress and equivalent stress generated in E-glass are

within acceptable limits, as well as total deformation. It also reveals that E-glass is more suited than steel for the same load carrying capability, allowing for a 60-68 percent weight reduction and an improvement in stiffness.

Nagarjuna et al. (2013) designed a chassis frame for an all-terrain vehicle and its optimization. Various loading experiments like Front Impact, Rear Impact, Side Impact, Roll Over test, among others, were performed on the chassis, and the design was optimized by decreasing the weight of the chassis. The material that was utilized for the optimization was IS3074. There was a considerable reduction in the weight of the roll cage, which helped it move faster. Optimization was obtained by decreasing the diameter of the chassis bar wherever less load was acting on it and where there were fewer deformations. By this process, the weight of the chassis was decreased from 84 kg to 64 kg by performing different loading analysis tests on the roll cage.

Rajappan and Vivekanandhan (2013) studied the static and dynamic load features of chassis utilizing FE models developed in the study. By analyzing vibration, natural frequency, and mode shape with the finite element approach, it was found that several high-stress areas exist. The specified features, such as mass density and Poisson's ratio, were adjusted to update the modal features of the truck chassis model. The predicted natural frequency and mode shape were compared to previously published data. Finally, adjustments to the new FE truck chassis model have been recommended to reduce vibration, improve strength, and optimize the truck chassis' weight. Bhaskar et al. (2014) investigated the static and dynamic response of truck chassis as a result of road undulations. The geometric modeling of the several components of the chassis was done in part mode as 3D models using Pro/ENGINEER 2001 software. The section features, viz, cross-sectional area details of the 3D modeled parts, were analyzed using the modeling software. The finite element model of the chassis was created using the ANSYS 7.1 package.

METHODOLOGY

Data Collection of Varying Loads of the Motor King

Data was collected from 20 motor king operators on how they load their machines with goods such as maize, rice, groundnut, cement, and sheanut (that is, the weight of each load). We had the number of bags of maize, rice, sheanut, groundnut, and cement that each respondent carries on their motor King. From our data, the mass of a bag of sheanut, maize, groundnut, rice, and cement is 85 kg, 100 kg, 95 kg, 100 kg, and 50 kg, respectively. The average loading of goods such as maize, rice, groundnut, cement, and sheanut was obtained to be 1240 kg, 1160 kg, 943.5 kg, 1282.5 kg, and 1155 kg, respectively.

Modelling of Motorized Tricycle Chassis Using ANSYS Software

The chassis of the motorized tricycle was modeled using ANSYS software. This was done by visiting the Tamale branch of Motor King to take measurements of the motorized tricycle 200ZH-E frame. The chassis, specifically the frame, was then modeled using ANSYS according to the dimensions of the 200ZH-E motorized tricycle. Figure 1 shows the I-section of the 200ZH-E motorized tricycle frame, and Figure 2 shows the model of the 200ZH-E chassis using ANSYS.

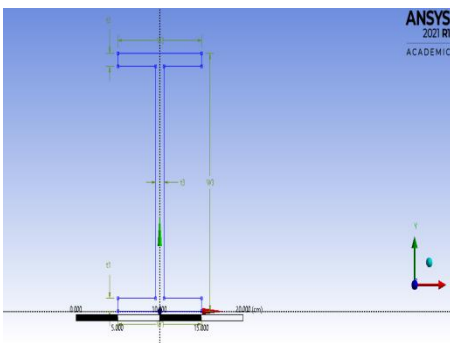


Figure 1: I-Section of the 200ZH-E motorized

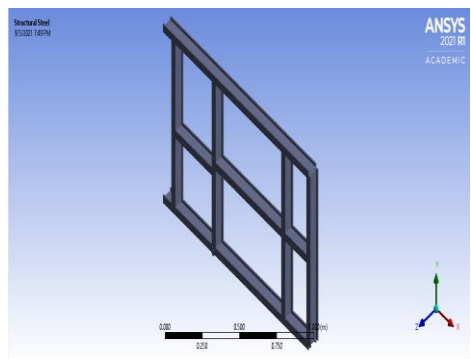


Figure 2: Modeled Chassis Using ANSYS tricycle Frame

Dynamic Analysis of Chassis Using ANSYS Software

ANSYS software was used to perform the dynamic analysis of motorized tricycle chassis. The dynamic analysis was performed entirely in the frequency and time domains. Dynamic features such as natural frequencies, mode shapes, and total deformation were determined through modal and harmonic response analysis in the frequency domain. On the other hand, transient structural analysis was performed in the time domain to determine the influence of varying loads on the motorized tricycle's chassis. First, modal analysis was performed, followed by harmonic response analysis to determine dynamic features (natural frequencies, mode shapes, and total deformation), and then, finally, transient structural analysis was performed to determine the impact of varying loads on the motorized tricycle's chassis.

RESULTS AND DISCUSSION

Results of Modal Analysis

Modal analysis enables us to investigate the vibration characteristics, such as natural frequencies, mode shapes, and total deformation of the chassis under specific boundary conditions. From the modal analysis, the natural frequencies, modes, and total deformation of the motorized tricycle chassis were obtained. Table 1 shows ten modes and their corresponding natural frequencies.

Table 1: The results of modal analysis

Modes	Natural Frequencies /Hz	Maximum Total Deformation/cm
1	117.32	0.23384
2	152.44	0.30635
3	286.03	0.32362
4	288.23	0.49294
5	290.84	0.35661
6	293.01	0.49589

7	340.73	0.39217
8	372.48	0.30963
9	381.25	0.4933
10	445.72	0.17905

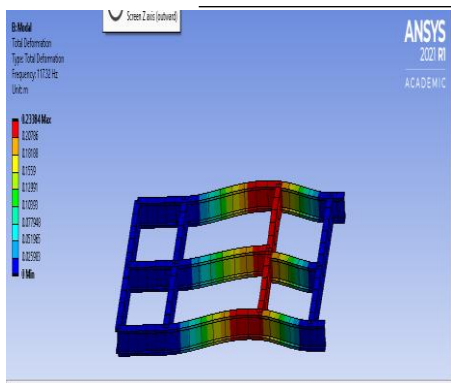


Figure 3: Mode 1 and its Corresponding Shape

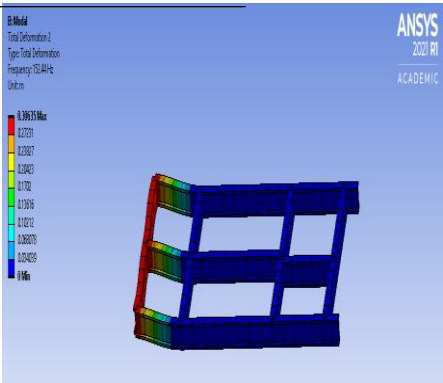


Figure 4: Mode 2 and its Corresponding Shape

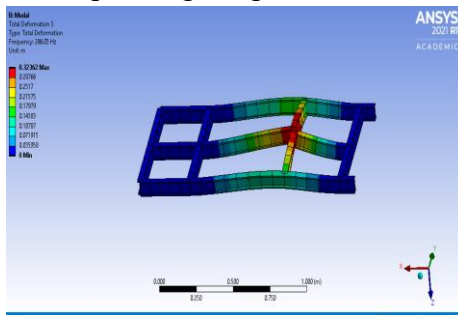


Figure 5: Mode 3 and its Corresponding Shape

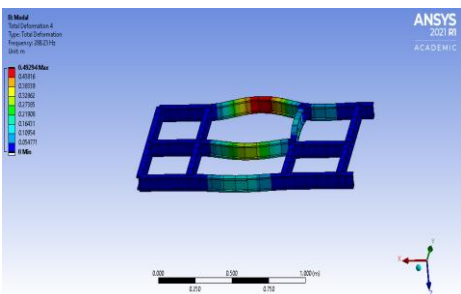


Figure 6: Mode 4 and its Corresponding Shape

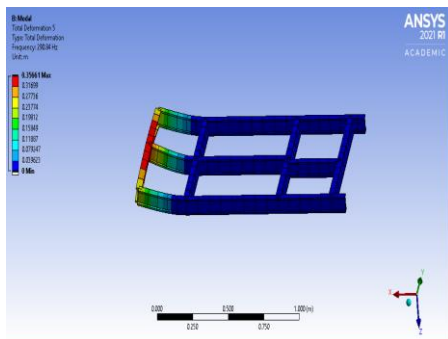


Figure 7: Mode 5 and its Corresponding Shape

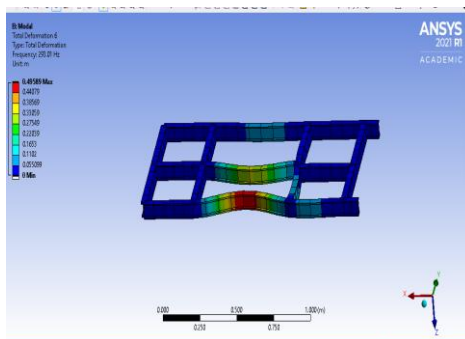


Figure 8: Mode 6 and its Corresponding Shape

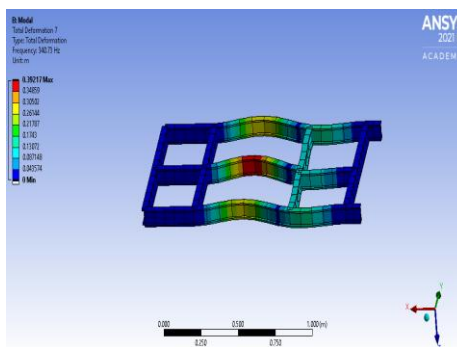


Figure 9: Mode 7 and its Corresponding Shape

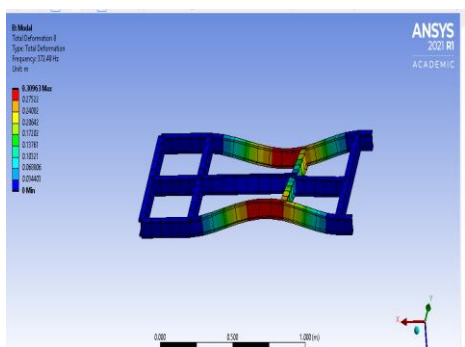


Figure 10: Mode 8 and its Corresponding Shape

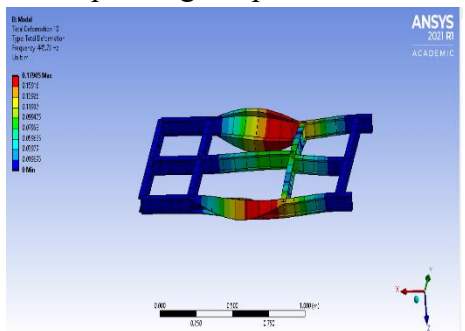
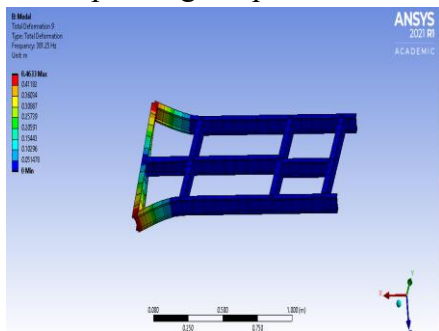


Figure 11: Mode 9 and its Corresponding Shape

Figure 12: Mode 10 and its Corresponding Shape

From Table 1, the results of modal analysis were obtained, which consist of the various modes, their corresponding natural frequencies, and maximum total deformations. From the table, the minimum frequency was obtained to be 117.32 Hz, and the maximum frequency was 445.72 Hz. Figures 3 to 12 show the various modes and their mode shapes. However, it must be noted that the results of a modal analysis are arbitrary and cannot be used for a real purpose because in modal analysis, no force is applied. But it is necessary to perform modal analysis because modal analysis is a prerequisite for harmonic response analysis. These results help us to perform harmonic response analysis easily and successfully.

Results of Harmonic Response Analysis

Harmonic response analysis helps us to get realistic results. A modal analysis is followed up by harmonic response analysis, where the geometry is subjected to different actual loads within certain frequency to determine frequency response and resonance frequencies. From the secondary data, the maximum load the motorized tricycle can contain is 500 kg. In addition to the maximum load, five average overloads (1240 kg, 1160 kg, 943.5 kg, 1282.5 kg, and 1155 kg) of different items are commonly carried by motorized tricycles in the Nyankpala community. All these loads were applied, and the corresponding maximum total deformations were recorded. The frequency ranges between 117.32 Hz and 445.72 Hz. The source of excitation was due to road roughness and overload of goods, which tends to increase the chassis' natural frequency. The harmonic response analysis was performed using the maximum load the tricycle can contain and the five average weights obtained from the data collection. Table 2 below shows the results of different loads.

Table 2: Varying Load and Total Deformation of Harmonic

Response	Loads/kg	Maximum Deformation/cm	Analysis
	500	0.00049567	
	943.5	0.00088764	
	1155	0.00101730	
	1160	0.00139560	
	1240	0.00149000	
	1282.5	0.00154000	

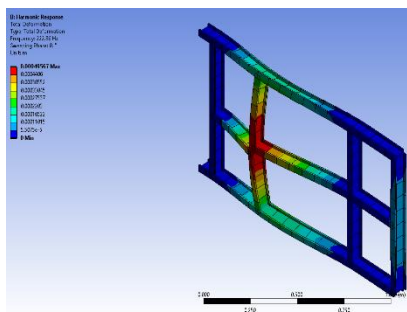


Figure 13: Total Deformation of 500 kg Load

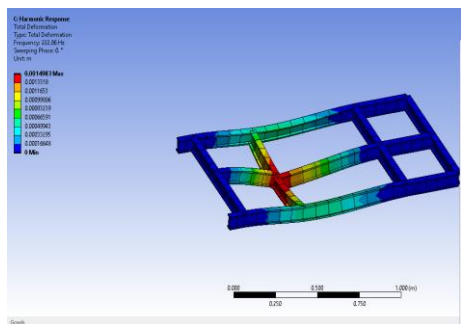


Figure 14: Total Deformation of 943.5 kg Load

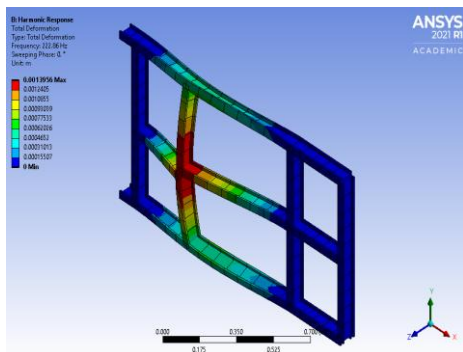


Figure 15: Total Deformation of 1155 kg Load

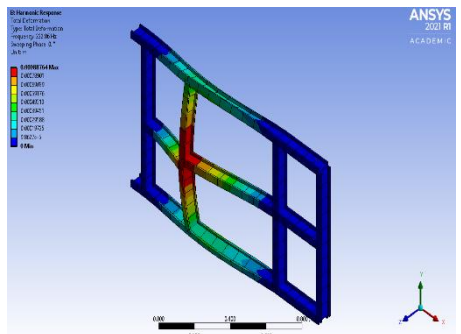


Figure 16: Total Deformation of 1160 kg Load

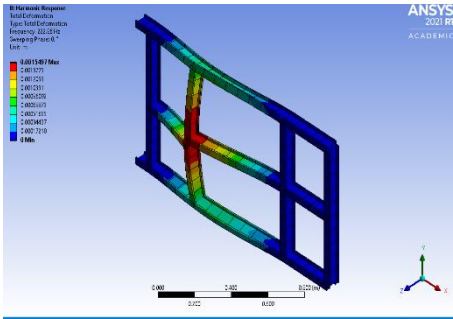


Figure 17: Total Deformation of 1240 kg Load

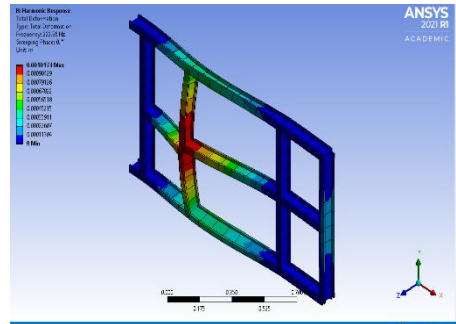


Figure 18: Total Deformation of 1282.5 kg Load

First, the frequencies of harmonic response analysis were determined by applying specific boundary conditions. These frequencies help to determine the vibration characteristics of chassis under the action of certain loads. It will also help us to determine the total deformation of the chassis under different boundary conditions. Figures 13 to 18 show the various loads and their corresponding total deformations.

From Table 2, when the load of 500 kg was applied to the chassis, the maximum total frequency was 222.86 Hz. The same frequency (222.86 Hz) was obtained when loads of 943.5 kg, 1155 kg, 1160 kg, 1282.5 kg, and 1240 kg were also applied. The load component in each load case uses the same factor and phase angle. Different load cases may have different factors and phase angles, but the frequency for all loads is the same. Also, Table 2 shows different maximum total deformations when varying loads were applied under a specific boundary condition. When the maximum loads of 500 kg, 943.5 kg, 1155 kg, 1160 kg, 1240 kg, and 1282.5 kg were applied, the maximum total deformations were obtained to be 0.00049567 cm, 0.00088764 cm, 0.00101730 cm, 0.00139560 cm, 0.00149000 cm, and 0.00154000 cm, respectively. It was observed that at the same frequency of 222.86 Hz, the maximum total deformation of the chassis of the motor king increases as the applied load increases. The frequency response curves for the overloading masses are shown in Figures 19 to 23.

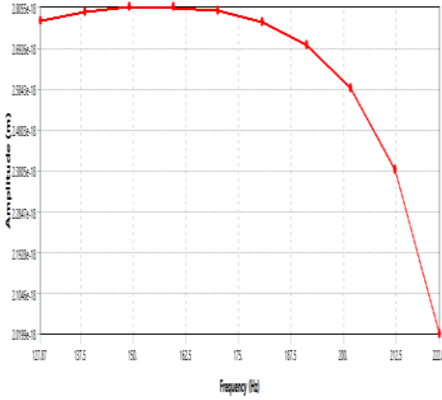


Figure 19: Frequency Response Curve for a Load of 1155 kg

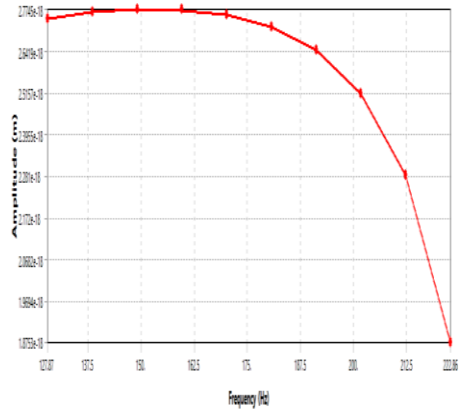


Figure 20: Frequency Response Curve for Load of 943.5 kg

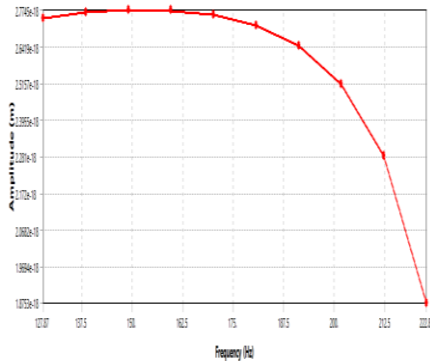


Figure 21: Frequency Response Curve for a Load of 1160 kg

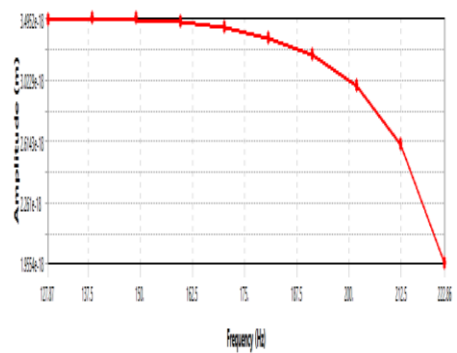


Figure 22: Frequency Response Curve for a Load of 1240 kg

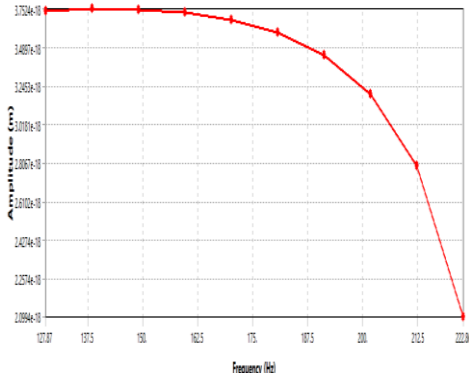


Figure 23: Frequency Response Curve for a Load of 1282.5 kg

The resonance frequencies of the chassis under the action of the varying loads were also determined from harmonic response analysis. The resonance frequency is the frequency that corresponds to the highest amplitude. From Figures 19 to 23, 148.75 Hz and 160 Hz are the frequencies that correlate to the highest amplitude. As a result, the resonance frequencies are 148.75 Hz and 160 Hz. The maximum amplitudes of the frequencies are the same in both cases. This means that when the chassis is subjected to vibrations at a frequency equal to or extremely close to its natural frequency, resonance will occur, which can lead to chassis failure.

Results for Transient Structural Analysis

It is used to calculate a structure's dynamic response under the influence of any broad time-dependent load. The motorized tricycle's chassis was subjected to a maximum load of 500 kg. A time step of 0.1 to 1.0 seconds was employed, with a 0.1-second interval. Below is the result for the highest overall deformation at 1 second.

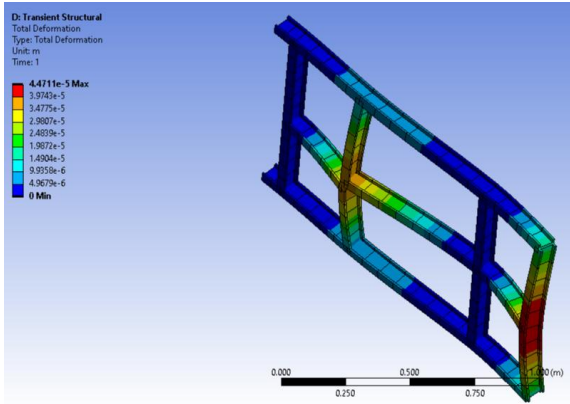


Figure 24: Result for Transient Analysis

From Figure 24, the maximum total deformation at 1 second when a maximum load of 500 kg was applied can be obtained. From the figure, maximum total deformation was found to be 4.4711×10^{-5} cm. This can help us explain the dynamic response of a structure under the action of time time-dependent load of 500 kg. With a total deformation of 4.4711×10^{-5} cm, we can evaluate the impact of 500 kg on the chassis of the motor king.

CONCLUSION

This article has discussed the process of dynamic analysis of a motorized tricycle chassis. The main and specific objectives of the project were achieved by modelling the chassis and performing dynamic analysis on it using ANSYS software. The dynamic parameters of the chassis, such as the natural frequency, mode shapes, and total deformation, were determined using modal and harmonic response analysis. The impact of varying loads on the chassis was evaluated using transient structural analysis. In the harmonic response study, the maximum load of the motorized tricycle of 500 kg (according to design specifications) was used, and the total deformation was recorded. Also, average overloading of 943.5 kg, 1240 kg, 1160 kg, 1282.5 kg, and 1155 kg was also applied, and their total deformations were recorded. It was observed that at the same frequency of 222.86 Hz, the maximum total deformation of the chassis of

the motor king increases as the applied load increases. The total deformation when the minimum load (500 kg) was applied was 0.00049567 cm (4.96 μ m), and that of the maximum load (1282.5 kg) was 0.00154 cm (15.4 μ m). This shows that the higher the load applied to the chassis, the higher the total deformation.

Also, the resonance frequencies for all the varying loads were 148.75 Hz and 160 Hz. This implies that resonance will occur when the chassis is subjected to vibrations at a resonance frequency equal to or very close to its natural frequency, which can cause chassis failure. Finally, the dynamic response of the chassis under the action of time-dependent load (500 kg) was determined using the transient structural analysis, and the maximum total deformation was found to be 4.4711×10^{-5} cm.

ACKNOWLEDGEMENT

The authors are grateful to God for his guidance and support.

CONFLICT OF INTEREST DECLARATION

The authors declare that there is no conflict of interest.

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ASSESSING THE RELATIONSHIP BETWEEN NUTRITIONAL STATUS AND ACADEMIC PERFORMANCE OF JHS PUPILS IN BUNKPURUGU-NAKPANDURI DISTRICT

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ABSTRACT

Academic performance is assessed through marks and educational goals set by teachers and students. Inadequate nutrition and health can negatively influence children's education, impairing both their academic performance and physical development. This study investigates the relationship between nutritional status and academic performance among Junior High School (JHS) pupils in the Bunkpurugu-Nakpanduri district of the North East Region of Ghana. The study utilized an Analytical Cross-sectional design and involved 403 JHS adolescent participants. Nutritional status was measured using Body Mass Index (BMI). Data collection was conducted through structured interviews, and statistical analysis was performed using SPSS. Participants were categorized into underweight, normal weight, overweight, or obese, and their academic performance was correlated with these categories. Approximately half of the students were found to be underweight, which significantly impacted their cognitive and academic abilities. Nearly half of the participants had a normal BMI. Although there was a small proportion of overweight and obese pupils, nutritional status alone did not significantly determine academic performance (p -value = 0.403). A significant association was found between class level and academic performance (p = 0.013). High dietary diversity (94%) was also discovered. Despite this, 63.8% of students scored low-grade points. The study underscores that academic achievement is influenced by various factors beyond nutritional status, including socio-economic conditions, educational quality, and

psychological well-being. Recommendations include implementing nutritional education, conducting regular health screenings and promoting physical activity. Future research should adopt a holistic approach, considering both nutritional and non-nutritional factors, and involve longitudinal designs and larger sample sizes to better understand the complex interplay between nutritional status and academic performance.

Keywords: Nutritional status, Academic performance, Educational goals, Teacher, Pupil

INTRODUCTION

The relationship between nutritional status and academic performance is critical and well-documented. Well-nourished children tend to excel academically due to enhanced cognitive capabilities, better health, and higher school attendance rates. Conversely, undernourished children face significant challenges, including increased susceptibility to infections, reduced cognitive function, and lower academic performance (Zerga et al., 2022; Soliman et al., 2021; Saavedra & Prentice, 2023). Therefore, ensuring adequate nutrition for children is paramount for fostering their educational success.

Globally, malnutrition persists as a significant public health concern, impacting individuals across all nations. Approximately 1.9 billion adults worldwide face issues of being overweight, while 462 million grapples with underweight conditions. More than 230 million children worldwide are affected by malnutrition, with 148.1 million being overweight, 45 million experiencing wasting, and 37 million suffering from stunting (UNICEF et al., 2023). Malnutrition is linked to 2.6 million annual deaths and the impediment of somatic and mental development in over 450 million children (Ayalew et al., 2020).

Academic performance, which is the knowledge gained assessed by marks from a teacher and the educational goals set by teachers and students, can be understood as the quantifiable and apparent behaviour of a student within a definite period. It is an aggregate of scores fetched by a scholar

in various evaluations through class tests, mid-term, and end-of-semester examinations (Tadese et al., 2022; Yusuf, 2016).

In Ghana, the situation is equally concerning. The 2022 Ghana Demographic and Health Survey (GDHS) reveals alarming statistics for children under five: 18% are stunted, 12% are underweight, 6% are wasted, and 2% are overweight (Viera Valencia & Garcia Giraldo, 2019). These figures highlight the severe public health challenge that could hinder the educational and developmental prospects of many children. Anthropometric indices, frequently employed for evaluating nutritional status, health, and development, underscore the intricate relationship among dietary intake, diseases, health practices, and educational achievements (D. S. A. Khan et al., 2022). Undernutrition adversely affects academic performance, intellectual development, and school attendance, while good nutrition is associated with enhanced cognitive and behavioural talents and improved school attendance (Ayalew et al., 2020). There is a growing concern regarding the nutritional status of school-aged children and its potential impact on their academic performance in the Bunkpurugu district, located in North East Region of Ghana. This concern arises from the observation that the region faces numerous socio-economic challenges, and access to proper nutrition and healthcare services may be limited for many families (*ASSEMBLY BUNKPURUGU/NAKPANDURI DISTRICT* 2020).

This research aims to assess the relationship between nutritional status and academic performance among JHS pupils in the Bunkpurugu-Nakpanduri District. Insights gained will facilitate the development of targeted interventions and strategies tailored to the specific needs of Junior High School pupil in the Bunkpurugu district.

MATERIALS AND METHODS

Study Area, design and Population

Bunkpurugu Nakpanduri District serves as the focal point for our project research. Situated in the eastern sector of the North East Region of Ghana. The study employed a cross-sectional design to assess the relationship

between nutritional status and academic performance in JHS pupils in Bunkpurugu-Nakpanduri District. The study was carried out among selected Junior High School pupils in Bunkpurugu-Nakpanduri District.

Sample Size determination

The minimum sample size for this study was determined using Cochran's formula. According to a study conducted by Appiah and Amos (2014), the prevalence of stunted pupils was 50%.

$$n = \frac{z^2 \times p(q)}{ME^2}$$

Where n = Sample Size

Z = z-score of the confidence level (95%) = 1.96

p = prevalence of stunting = 50 % = 0.5

q = 1 - p = 1 - 0.5 = 0.5

ME = Margin of error (5%)

n = 384.16 = 384

For non-response 5% = 0.05 x 384 = 19.2 = 19

Sample size of pupils = 384 + 19 = 403

Therefore, 403 JHS pupils were recruited into the study.

Sampling Technique

Multi-stage sampling method was used to select the 403 respondents. The district is stratified into three-circuits. A sample size was proportionately allocated to each stratum based on number of schools in each circuit. For each stratum, a school or two was randomly selected. Based on the sample size calculated for each stratum and the total population of each school, proportionate allocation was used to select the number of pupils per school. Based on the sample size per school, proportionate allocation was used again to determine the number of pupils per class. Finally, the number of pupils per each class were randomly selected to participate in the study. Table 3.1 shows the distribution of schools by circuits in the study area and the number of pupils recruited.

Table 1: Distribution of schools

Circuit and schools.	Sample size	Percentage%
Bunkpurugu Central		
1. Zongo JHS	119	29.5
2. Salimbouku B JHS	101 81	25 20
Bunkpurugu West		
1. Nanyiar JHS		
Bunkpurugu East		
1. T. I Ahmadiyya JHS	102	25
Total	403	100

Data Collection Tools

Sociodemographic Characteristics: A questionnaire was administered to collect data on the participants' sociodemographic characteristics.

Height: A stadiometer was used to measure the height of the participants accurately.

Weight: The participants' weight was measured using a digital scale (Seca).

Academic Performance: Academic performance data was gathered from the terminal reports provided by the schools.

Data Collection Procedure

The data were collected through direct interview using a semi structured questionnaire. The questionnaire was developed to cover sections namely, Anthropometry such as weight and height, Academic performance using terminal reports, Socio-demographic characteristics such as age, gender, ethnicity etc. as well as Dietary diversity.

Study Variables

These refer to measurable characteristics or factors that are being studied or analyzed.

Dependent Variable

Academic Performance: We assessed the academic performance of the pupil by considering the average score of their terminal exams results for two previous semesters. The results were classified as follows: 0-49 being low grade point, 50-69 being good grade point and from 70-100 being an excellent grade point.

Independent Variables

Nutritional status

Nutritional status refers to the overall health and well-being of an individual as influenced by their diet and nutrition. It is a measure of the balance between the nutrients the body takes in through food and the nutrients it needs to function properly. The nutritional status of the pupil will be assessed using anthropometric measurements. Weight and height were measured for BMI of study participants and classified as less than 18.5kg/m^2 being underweight, greater than or equal to 18.5 to 24.9kg/m^2 being normal, from 25 to 29.9kg/m^2 being overweight and greater than or equal to 30kg/m^2 being obese.

Socio-economic and demographic characteristics

The study assessed the socio-economic characteristics such as occupation, employment status, educational level, age, gender, ethnicity and religion.

Anthropometric measurement

Height: A Seca stadiometer that is scaled to the closest 0.1 cm was used to measure the height of participants. The subjects were required to stand straight on the stadiometer's level stand, both feet together and barefoot, with their arms by their sides. Before taking readings, the participants' eyes were pointed straight ahead as the top sliding portion of the stadiometer was adjusted slightly to the crown of their heads. Two measurements of height were made, and the average of the two was determined. For weight measurement, an electronic weighing scale was used. This device's reading was always set to zero. It was placed on a hard, level surface. On the weighing scale, subjects were instructed to stand with their backs straight and to stare straight ahead. Additionally, weight

measurements were made twice, with the mean being calculated. The body mass index (BMI) was employed to evaluate the participants' nutritional condition. The World Health Organization (2007) defines the body mass index (BMI) as follows: underweight (<18.5), normal (18.5-24.99), overweight (25-29.99), and obese (≥ 30). The BMI was calculated by dividing the weight (kg) by the square of the height.

Dietary Diversity

Seventeen (17) questions were asked on various food groups and food items and a score of one (1) was given to anyone who consumes from a food group or consumed a food item on the list. The results were classified as 5 and above being met and less than 5 being not met.

Data Analysis

Data analysis was done using Statistical Package for Social Science (SPSS version 21.0).

Results were presented in tables and figures. The results on categorical variables were reported on frequencies and percentages. The Pearson's chi-square test of independence was used to assess associations of nutritional status with dietary diversity and academic performance of the participants. The test of statistical significance was determined at $p \leq 0.05$.

Ethical Consideration

Ethical clearance was obtained from the University for Development Studies Institutional Review Board (UDSIRB) with reference number UDS/RB/025/24. An official introductory letter was obtained from the Department of Nutritional Sciences of the University for Development Studies to the schools in the study area. Permission was sought from the Bunkpurugu-Nakpanduri District Education Office, the Headteachers of the selected schools. Participation in the study was voluntary and respondents were assured of confidentiality of their responses.

THE RESULTS

Socio-Demographic Characteristics

According to the study findings, 200(49.6%) were males, 203(50.4%) females. Majority of the participants, 218(54.1%), were within the age range of 11-15 years. The findings also revealed Christianity as the predominant religion among the participants with 309(76.7%). The research disclosed that majority of the participants were Bimobas 366(90.8%) and lived in household with sizes ranging from 6 - 10 members 284(70.5%). The study showed that most of the participants' fathers, 287(71.2%) and mothers, 226(56.1%) were farmers. Many participants' fathers had no formal education 170(42.2%). Also, majority of the participants mothers 240(59.6%) had no formal education. Additionally, 68(16.9%) of the participants fathers and 80(19.9%) of the participants mothers had their educational level up to primary school. Furthermore, 78(19.4%) of the participants fathers and 51(12.7%) of the participants mothers had their education to the JHS level. Moreover, 45(11.2%) of participants fathers and 20(5.0%) of participant mothers had their education to the SHS level. And 42(10.4%) of participants fathers and 12(3.0%) of participants mothers had their education to the tertiary level. The participants were distributed across different class levels with 133(33.0%) participants in JHS1, 102(25.3%) participants in JHS2, and 168(41.7%) participants in JHS3.

Table 2: Socio-Demographic Characteristics

Variable	Frequency(N)	Percent (%)
Gender		
Male	200	49.6
Female	203	50.4
Age		
6-10	3	0.7
11-15	218	54.1
16-20	182	45.2

Religion

Christianity	309	76.7
Islam	92	22.8
Traditionalist	2	0.4

Ethnicity

Bimoba	366	90.8
Moshie	7	1.7
Hausa	11	2.7
Dagomba	14	3.5
Others	5	1.2

Household size

1-5	67	16.6
6-10	284	70.5
11-15	48	11.9
16-20	4	1

Father's**Occupation**

Teacher	31	7.7
Farmer	287	71.2
Health professional	5	1.2
Trader/Business	49	12.2
Others	31	7.7

Mother's**Occupation**

Teacher	13	3.2
Farmer	226	56.1
Health professional	2	0.5
Trader/Business	122	30.3
Others	40	9.9

Father's Education level

None	170	42.2
Primary	68	16.9
JHS	78	19.4
SHS	45	11.2
Tertiary	42	10.4

Mother's Education level

None	240	59.6
Primary	80	19.9
JHS	51	12.7
SHS	20	5.0
Tertiary	12	3.0

Class level

JHS1	133	33.0
JHS2	102	25.3
JHS3	168	41.7
Total	403	100

Note: others-occupation (carpenter, driver, mason,) others-ethnicity (fulaani, frafra, mamprusi)

Dietary Intake

Almost all the participants, 402(99.8%), consume foods from cereals or cereal products. The majority of participants, 236(58.6%), consume vitamin A-rich vegetables and tubers. In addition, a significant portion of the participants 268(66.5%), consume white tubers and roots. Furthermore, most participants 364(90.3%), consume dark green leafy vegetables. Moreover, an overwhelming majority of participants, 392(97.3%), consume other vegetables. and 385(94.1%) consume vitamin A rich fruit. Also, less than half of the participants, 190(47.1%), consume other fruits. Moreover, 237(58.8%) consume organ meat and a majority 321(79.7) % consume flesh meat. More also, 263(65.3%) consume eggs and 366(90.8%) consume fish. Majority 331(82.1%) consume foods from

legumes, nuts and seeds. Furthermore 227 (56.3%) consume milk and milk products and 371 (92.1%) consume foods from oils and fats. Additionally, 244(60.5%) consume red palm products, 296 (73.4%) consume sweets and 218 (54.1%) consume spices, condiments and beverages.

Table 3: Dietary Intake

Variables	Response	Frequency	Percent
Cereals	No	1	.2
	Yes	402	99.8
Vitamin A Rich Vegetables and Tubers	No	167	41.4
	Yes	236	58.6
White Tubers and Roots	No	135	33.5
	Yes	268	66.5
Dark Green leafy Vegetables	No	39	9.7
	Yes	364	90.3
Other Vegetables	No	11	2.7
	Yes	392	97.3
Vitamin A Rich Fruits	No	18	4.5
	Yes	385	95.5
Other Fruits	No	213	52.9
	Yes	190	47.1
Organ Meat Iron Rich	No	166	41.2
	Yes	237	58.8
Flesh Meat	No	82	20.3

	Yes	321	79.7
Eggs	No	140	34.7
	Yes	263	65.3
Fish	No	37	9.2
	Yes	366	90.8
Legumes Nut and Seeds	No	72	17.9
	Yes	331	82.1
Milk and Milk Product	No	176	43.7
	Yes	227	56.3
Oils and Fat	No	32	7.9
	Yes	371	92.1
Red Palm Product	No	159	39.5
	Yes	244	60.5
Sweets	No	107	26.6
	Yes	296	73.4
Spices Condiments Beverage	No	185	45.9
	Yes	218	54.1

Nutritional Status

According to the study findings, 209(51.9%) participants had BMI less than 18.5kg/m² which indicates that they are underweight. Also, 188(46.7%) participants had BMI within the range of 18.5 – 24.9km/m²

which indicates normal weight. Moreover, 5(1.2%) participants had BMI within the range of 25-29.9kg/m² which shows that they are overweight. Additionally, 1(0.2) participant had a BMI within the range of 30-39.9kg/m² which indicates that he/she is obese.

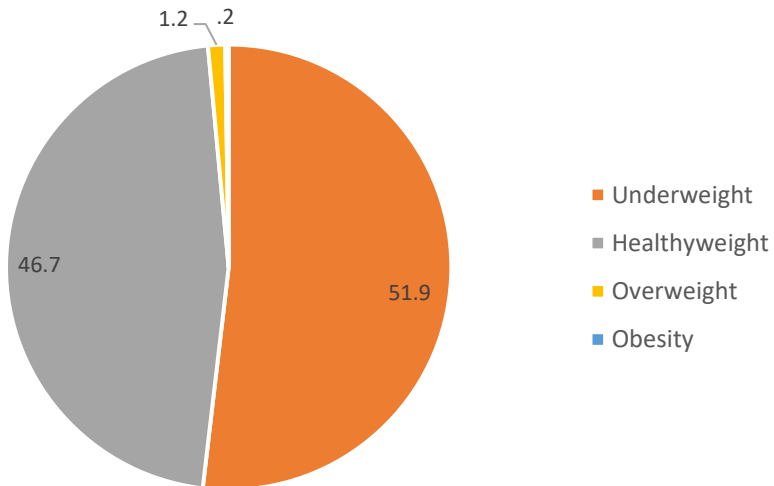


Figure: 1: Body Mass Index

Minimum Dietary Diversity

There were 10 food groups and anyone who had a score of 5 and above met their Minimum Dietary Diversity while anyone who had a score below 5 did not meet their Minimum Dietary Diversity. Minimum Dietary Diversity score for women were used in accordance with Hanley-Cook et al., (2024) on the dietary intake and dietary diversity of adolescents. According to the research findings, 379(94%) of the study participants consumed five or more of the food groups which indicates that they have met their minimum dietary diversity while 24(6%) of the study participants consumed less than five of the food groups hence did not meet their minimum dietary diversity.

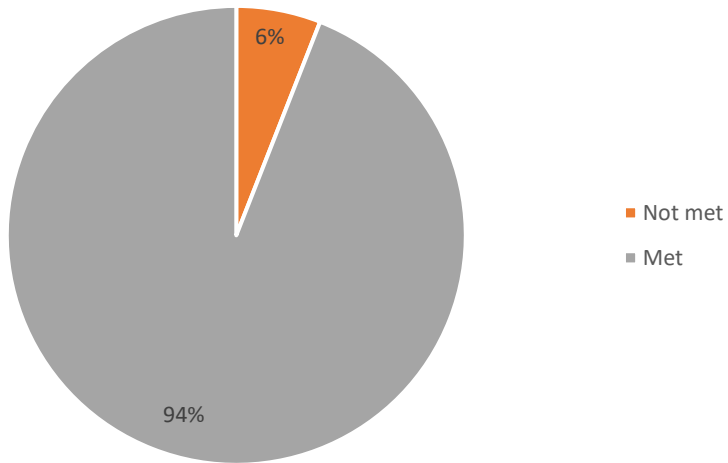


Figure 2: Minimum Dietary Diversity Grade Point

First and second semester results for each subject that is English Language, Mathematics, Integrated Science and Social Studies were used and the average was taken as the grade point. An average score below 50 was classified as low GPA ranging from 2.0-1.0; Scores between 50-69 were classified as good GPA ranging from 2.5-3.5; while scores above 69marks were classified as excellent GPA ranging from 4.0-5.0 GPA. The majority (63.8%) of the study participants scored below 50% indicating a low-grade point; 32.3% scored between 50% - 60% which is interpreted as a good grade point while 4.0% scored above 60% which is construed as an excellent grade point.

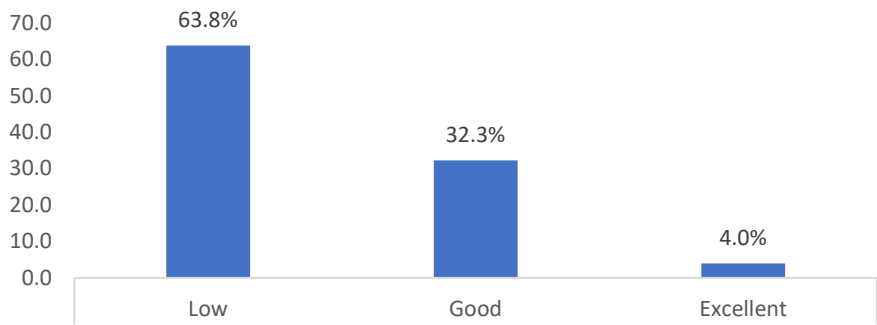


Figure 3: Grade point

BMI Categorized and Grade point Cross tabulations

Among those with an underweight BMI, 65.6% scored a low-grade point, 31.6% scored a good grade point, and 2.9% scored an excellent grade point. For respondents with a healthy weight BMI, 61.7% scored a low-grade point, 33.5% scored a good grade point, and 4.8% scored an excellent grade point. Among participants with an overweight BMI, 60% scored a low-grade point, 20% scored a good grade point, and 20% scored an excellent grade point. All respondents with an obesity BMI, 100%, scored a low-grade point.

Table 4: Association between nutritional status, dietary diversity, class level, gender, parents’ level of education, parents’ occupation and academic performance.

VARIABLE	GRADE POINT			<i>p</i> -value
	Low	Good	Excellent	
BMI				
Underweight	137(65.6)	66(31.6%)	6(2.9%)	0.403
Healthy weight	116(61.7)	63(33.5%)	9(4.8%)	

Overweight	3(60%)	1(20%)	1(20%)
Obesity	1(100%)	0(0%)	0(0%)

MDD

Met	245(64.6)	129(34%)	5(1.3%)	0.319
Not Met	12(50%)	12(50%)	0(0%)	

**CLASS
LEVEL**

JHS1	93(69.9%)	40(30.1%)	0(0%)	0.013
JHS2	56(54.9%)	46(45.1%)	0(0%)	
JHS3	108(64.3)	55(32.7%)	5(3.0%)	

GENDER

Male	131(65.5)	66(33.0%)	3(1.5%)	0.644
Female	126(62.1)	75(36.9%)	2(1.0%)	

MOTHERS' LEVEL OF EDUCATION

None	154(64.2)	83(34.6%)	3(1.3%)	
Primary	46(57.5%)	32(40.0%)	2(2.5%)	
JHS	37(72.5%)	14(27.5%)	0(0%)	0.759
SHS	13(65.0%)	7(35.0)	0(0%)	
Tertiary	7(58.3%)	5(41.7)	0(0%)	

FATHERS' LEVEL OF EDUCATION

None	111(65.3)	58(34.1%)	1(0.6%)	
Primary	42(61.8%)	25(36.8%)	1(1.5%)	
JHS	56(71.8%)	20(25.6%)	2(2.6%)	0.084
SHS	21(46.7%)	24(53.3%)	0(0%)	
Tertiary	27(64.3%)	14(33.3%)	1(2.4)	

MOTHERS' OCCUPATION

Teacher	8(61.5%)	5(38.5%)	0(0%)	
Farmer	141(62.4)	83(36.7%)	2(0.9%)	
Health professional	2(100%)	0(0%)	0(0%)	0.083
Trader	81(66.4%)	39(32.0%)	2(1.6%)	
Others	25(62.5%)	14(35.0%)	1(2.5%)	

FATHERS' OCCUPATION

Teacher	20(64.5%)	11(35.5%)	0(0%)	
Farmer	176(61.3)	108(37.6)	3(1.0%)	
Health professional	3(60.0%)	1(20.0)	1(20.0%)	0.143
Trader	36(73.5%)	13(26.5%)	0(0%)	
Others	22(71.0%)	8(25.8%)	1(3.2%)	

Note: others-occupation (carpenter, driver, mason,) others-ethnicity (fulaani, frafra, mamprusi)

According to the research findings, there is a significant statistical association between class level and academic performance of the study participants, $p=0.013$. However, no significant statistical association was found between nutritional status, dietary diversity, gender, parents' occupation, parents' level of education and academic performance of the study participants.

DISCUSSION

The relationship between nutritional status and academic performance among JHS pupils is a critical area of study, particularly in rural, low-income settings. According to the study, about half of the study participants had a BMI less than 18.5 kg/m², indicating that they are underweight. This high prevalence of underweight status suggests a significant concern with undernutrition among the students. Undernutrition during childhood and adolescence can have profound impacts on cognitive development, physical health, and overall well-being. It can lead to decreased academic performance due to issues such as lack of energy, impaired cognitive function, and frequent illnesses (Govender et al., 2021). Addressing undernutrition through targeted

nutritional interventions and ensuring access to adequate food resources is crucial for this population.

Conversely, closer to half of the study participants had their BMI within the range of 18.5–24.9 kg/m², which is considered normal. This indicates that nearly half of the participants have a healthy weight, suggesting that they are likely receiving adequate nutrition to support their physical and cognitive development. Maintaining a normal BMI is associated with better health outcomes and academic performance, as it typically reflects balanced dietary intake and adequate physical activity (Oukheda et al., 2023).

most of the study participants (94%) met their minimum dietary diversity. This high percentage suggests that most of the pupils are consuming a variety of foods that likely provide a range of essential nutrients necessary for growth, development, and cognitive function. Adequate dietary diversity is associated with improved nutritional status, which supports better health outcomes and academic performance. Consuming a variety of foods helps ensure that children receive the necessary vitamins, minerals, and macronutrients to support their physical and cognitive development (Roberts et al., 2022). The access to a diverse diet may be attributed to various factors, such as household food security and nutritional knowledge. Ensuring that children continue to meet their dietary diversity requirements is crucial for maintaining and improving their health and academic outcomes (Weerasekara et al., 2020).

More than half of the study participants (63.8%) scored a low-grade point. This high percentage of students with low academic performance raises concerns about potential underlying issues, including nutritional deficiencies. Poor nutrition, particularly undernutrition, has been shown to adversely affect cognitive development, concentration, and overall school performance. Children who are undernourished, are more likely to experience fatigue, reduced cognitive abilities, and frequent illnesses, all of which can hinder their ability to perform well academically (Amoadu et al., 2024). The high prevalence of low grades among the participants suggests that nutritional interventions and support systems may be

necessary to improve their academic outcomes. On the other hand, 32.3% of the study participants scored a good grade point. This group represents students who are likely receiving adequate nutrition and benefiting from a supportive learning environment. A small fraction of the participants (4.0%) scored an excellent grade point, indicating exceptional academic performance. Excellent academic performance is often associated with a stable home environment, access to educational resources, and adequate nutrition. These students may also exhibit higher levels of motivation, better study habits, and greater overall well-being (Capuno et al., 2019). Poor nutritional status, as indicated by a high prevalence of low BMI among the students, correlates with lower academic performance. This agrees with a study that was conducted by Asmare et al., (2018).which found that the low level of educational performance was significantly higher ($p < 0.05$) among the stunted, underweight and wasted children than that of the normal children.

From the findings of the study, there was no significant association between academic performance and nutritional status among the study participants. However, among the study respondents, 65.6% had a BMI indicating underweight and scored low-grade points. The finding is consistent with a study by Amoadu et al., (2024) which says that undernourished children often face challenges such as fatigue, reduced concentration, and higher susceptibility to illness, all of which can negatively impact their academic achievements. This suggests that while there are observable trends linking nutritional status and academic performance, these trends are not statistically significant in this sample. The lack of a significant association could be due to the influence of various confounding factors such as socio-economic status, quality of education, psychological well-being, and home environment, which were not controlled for in this study.

LIMITATIONS

The time gap between when the exams used to compute academic performance were taken and when the BMI was measured to assess the nutritional status of the pupil. The study could not measure the causal

effects of the variables. The stipulated time for the study was over a short period of time.

CONCLUSION

The study discovered high prevalence of underweight status (51.9%) among students, indicating significant concerns with undernutrition. A considerable proportion of students (46.7%) had a normal BMI, suggesting that they receive adequate nutrition to support their physical and cognitive development. A small fraction of students was found to be overweight (1.2%) or obese (0.2%), underscoring the dual burden of malnutrition in the study population. Additionally, high dietary diversity was observed among the majority of students (94%). However, a concerning trend of low academic performance was noted, with 63.8% of students scoring low-grade points, potentially linked to poor nutritional status. Despite these findings, the chi-square test indicated no statistically significant association between nutritional status and academic performance ($p\text{-value} = 0.403$). However, there was a significant statistical association between class level and academic performance of the study participants, $p=0.013$.

RECOMMENDATION

Further research is needed to comprehensively understand the complex interplay between nutritional status and academic performance. Future studies should consider longitudinal designs to track changes in nutritional status and academic performance over time, larger sample sizes to increase the power of statistical analyses and the validity of findings, and the inclusion of additional variables such as quality of education, home environment, and psychological well-being to control for potential confounding factors.

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**EFFECT OF GENDER-SENSITIVE ACCESS TO CLIMATE
INFORMATION SERVICES ON CLIMATE SMART
AGRICULTURE USES: CASE OF STAPLE FOOD SUPPLY
CHAIN IN NORTHERN GHANA**

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ABSTRACT

Faculty of Agriculture, Food and Consumer Sciences, Department of Agriculture and Food Economic, University for Development Studies, Ghana Department of Geoscience and Natural Resource Management, University of Copenhagen, Denmark Abstract Despite declining macro-economic impact of agriculture, its performance is still impulsed by the smallholder where the gender roles and responsibilities is highly disproportionate. The present study aims at providing comparative analysis of access to Climate Information Services (CSI), and the effect of Climate Smart Agriculture (CSA) across gender among smallholders. It used the IFPRI secondary data of CSA in Northern Ghana. Since household head's age was missing, the study used only male and female as gender categories. The descriptive statistics showed that mixed households dominate with 91% of which only 29% are female-headed. Maize production ranked the highest with 78% of which male farmers represent 75% and female 25%. The most and quasi-equally experienced climate shocks are dry spell, post-harvest losses, crop damage and increase in agricultural input prices. The strategies adopted to face shocks and stresses are also gendered. Women engaged more in borrowing when agricultural input prices increase and the death of a household member occurred. Regarding the CSI access and CSA adoption, the ordered probit showed that these are diversely gendered. The most accessible CIS are

planting time, predicting rainfall, fertilizers application, variety selection and crop selection. The access is a matter of perception, awareness, proximity and contextual relevance. The men earn 2.09 more annual income and 1.40 more yield than women. The CSA uses are determined by the shocks experienced by farmers, annual income and poor quality of agricultural inputs. The study recommends expanding the study area and making.

Keywords: Gender-sensitive, Climate Information, Services, Climate Smart, Agriculture

INTRODUCTION

The extent of agricultural macro-economic impacts has declined Ghana since the discovery and production of oil. However, the economy alike majority of African countries has an which is till relying on agriculture sector's contribution (ACEP, 2020). The sector provides the income source for around 34% active population in the country and had the highest contributor to the GDP with 20%, and export earnings of 30% (FTA, 2020). This performance of rural sector in impulse by the smallholder farmers who constitute the cornerstone of the production sector. They dominate the sector in both numbers and outputs. According to the latter source, the smallholder farmers in the agricultural sector are up to 80% of the producers in the sectors. Amidst these ever-growing smallholders' contributions to the outputs, women contribute to the nation's subsistence crop by 70%, labour force by 52% and total GDP by 46% (UNDP, 2020 cited from FAO, 2012).

Despite the performance of Agriculture in Ghana, this crucial sector remains natural-based, solely dependent on unreliable natural rainfall. More than half of the country experiences unimodal rainfall pattern forcing into single cropping season bimodal rainfall pattern areas face frequent crop failures. This has dramatic consequences on the sector's short, medium and long runs. Both cash crops and staple food production are exposed, thus making the economy climate-sensitive (ACEP, 2020).

Despite their diversity across heterogeneous nature's geography, demography, ecology and socioeconomic, the smallholder farmers are the most vulnerable due to the climate variability and unpredictability (Kamara and Cooke, 2019). The changes in other atmospheric parameters and climate events such as rainfall, sporadic droughts, floods and heat stress are obvious in coming years, but with disproportionality according to country's ecological zones (Atiah, et al., 2020).

Under the direct spotlight of climate hazards, globalization and progress of new technologies, Ghana alike many of countries agricultural-based economy faces gradual transition from agricultural-led to industry-based and services economy. This drains the active hands out of the sectors and therefore lowers its contribution to the development of the countries (FTA, 2020). Hence, in the recent decades, the contribution of agriculture to the Ghanaian GDP has shrunk for more than 50% compared to its previous one. The challenges are similar at farm level where smallholder farmers face low yield and are unable to transit towards commercial-oriented farming as stipulated by national and ECOWAS regional policies, 2003 Maputo Declaration, African Agriculture Development Agenda and 2014 Malabo Declaration (CCAFS, 2021; Kamara and Cooke, 2019).

Government and partners have taken actions to address the negative impacts of the climate change and new socioeconomic modern life on agriculture via many national policies and international engagements (UNDP, 2019). The Climate Smart Agriculture (CSA) has been as better alternative in the context of smallholders disposing with mere means of productions, lack of access to finance, lack of modern technologies, machinery and equipment and lack of access to recent scientific discoveries for agriculture. It captures the "triple-win" of productivity, adaptation and reduced emission (Rubin and Ajayi, 2019). This is optimized management, maximize yield with minimum required inputs. Where appropriately adapted, the CSA improves farmers' resilience, food security and sustainable growth (Sain *et al.*, 2017). The CSA is linked to reduced vulnerability and improved build adaptive capacity to climate and

related stresses (Brandt et al., 2017). Shikuku (2017) shows its importance in integration of crop-livestock production systems.

The present study aims at providing comparative analysis of access to Climate Information Services (CIS) across gender and the effect of Climate Smart Agriculture (CSA) on smallholders' farm yield. To do so, the study will answer various questions such as: Is the CIS equally accessible across gender? Are CSA practices profitable? If yes, are they across gender? What are market and non-market benefits of CSA practices in the study area? What are gendered challenges of CSA practices among adopters? The paper is structured as follow. The chapter is dedicated to background knowledge, chapter II literature review that explores concept of the gender, definition, theories, analytical framework and limitations. The chapter describes the study methodology, data uses and statistical methods. The chapter displays the main findings of the study and political implications. The last chapter conclude about the findings and proposes some recommendations for further research and political decision. This is followed by the list of references that are used to conduct the study.

LITERATURE REVIEW

Concept of Gender

The Canadian Institute of Gender Health (IGH-Canada), the highest in the country, recognizes that though the social and biological distinction between sex and gender there is neither approved universal definitions nor simple clear-cut of these two terms since they are interconnected and hardly separable (IGH, 2023). Gender is socially ascribed traits to women, men and gender-diverse people that determine in the society their identity, roles, behaviours, relationships and relative position or power (Heidari, 2016). The author claims that sex, usually categorized as male and female, is anatomic, an attribute determined by a set of natural phenomena (biology) in human and other livings under influence of various mechanisms, physical and physiological. This biological determinism is natural-based, a result of chromosome x and y, gene expression, function of hormones, sexual reproduction and other anatomic characteristics.

Scott (1940) states that the definitions of gender and sex are dynamic as are the societies and sciences. In her historical analysis of gender, the author situated the historiographic process of gender as follows. The American feminists who seemingly were the first to use the term “gender” did so to reject the biological determinism or social distinction based on sex. The term “gender” referred also to normative definitions of femininity. Mehta and Henry (2017) warn that the latter should not be considered as either biologically based or connected to gender identity. Its linguistic usage defines a form of grammatical classification or words. Academicians who were interested to balance the overuse of men as social reference in research introduced the term into analytical vocabulary for a relational concept. They tried to understand the heuristic value of gender used.

The confusion about the terms emanates from political and ideological controversy within or outside anti-feminists who give less if not none attention to epistemological, methodological or theoretical aspects of gender versus sex debates (Nieto and Mayo, 2017). Culture, time and geopolitical space are also determinant in shaping their meanings (Mehta and Henry, 2017) As time goes on, many phrases have been used to explain “gender” or “women’s and men’s social ranking”, “Sex role” to point to behaviour, “sexual status” to point to social rankings, “psychological sex” and “sex-role identification” to refer to gained sense oneself as female or male (Meyerowitz, 2008). The terms “gender”, “gender role” and “gender role ad orientation” were introduced into scientific literature in 1950s by pioneer scientists (Money and colleagues (Money *et al.*, 1957).

Theorizing the nexus of gender-sex is complicated since the social and biological construct are overlapping (Nieto and Mayo, 2017). Menstruation can be a question of both sex and gender. If the menstruation is said to be of sex, then it becomes a biological construct. Oxymoronically, if it is required that all menstruating women must refuge themselves in a designated place such as the menstruation hut among Dogon people in Mali, then it is social construct meaning gendered

(Strassman, 2011). This ideology of indigenous religion that considers the menstrual pollution as supernatural has many social implications such as women's honesty to husbands, post-menstruation copulation, immanency of conception and cuckoldry risk. Scott (1940) accommodates the duality between biological determinism and social scientists by stating: gender is "a constitutive element of social relationships based on perceived differences between the sexes, woman and man" as well as "a primary way of signifying relationships of power."

The latter posit by Scott was depreciated by many women's historians such Judith Benetti, Linda Gordon and Joan Hoff (Meyerowitz, 2008). The former claimed that Scottian study of gender ignores women as women. The latter mainly reproaches Scottian to be "nihilism, ahistoricism, obfuscation and patriarchalism". She also found Scottian to undermine and disregard as a "category of analysis". Contemporary, in its daily usage the gender is mainly as "synonym of woman, sexual differences" (Meyerowitz, 2008). According to the author, this creeping "gender" into women's history has not yet managed to transform the field while the misspecification and misuse of the concept are imposing "false solidity" on this dynamic category of women and men. Consequently, like many other scholars, the author is sceptic about using the term "gender". It has been for long recognized that in real life there is terribly blur literature in distinguishing between "identity" and its related terms such as "self", "self-representation", "ego-identity", "sense of identity" and so forth (Stoller, 1968).

Gender Roles and Responsibilities in Agriculture

Gender roles and responsibilities emanate from beliefs, opinion and attitudes concerning them, which concomitantly mold the stereotypes that nurture one's conduct towards partner's status, gender or counter-group (García-Cueto et al., 20214). These social constructs shape the vulnerability levels of the different gender categories in a given society. They transmission is guaranteed by socializing agents which are family, schools and peer in the community (UNFCCC, 2023). Enduring social and

societal burdens, mindset, engagement, all decision-making process and bearing consequences are mainly forged by the same social constructs (IOM, 2019). The gender roles among rural dweller are paramount of importance regarding income growth, poverty and inequalities reductions, food security and household wellbeing. Compared to men, women are found to be the most multi-tasking, and spending more of their incomes on household wellbeing, food, education, health etc. (Menssah and Fosu-Mensah, 2020).

Gender roles and responsibilities in agricultural sector have temporal, spatial and cultural variation. Welk et al. (2022) found that these roles and responsibilities are diverse according to the types of crops, of plots and of on-farm activities. They found that tasks reserved to women are mainly planting, weeding, harvesting, threshing, drying and storing harvested crops, while men's tasks are slashing, burning and spraying grass with pesticides. The men are also responsible for preparing the garden such as ploughing and digging holes for planting, planting, adding fertilizers, harvesting, transport, packaging and storing, looking for a market and selling. The same gaps are noticeable and persistent in terms of productivity and asset ownership across the gender. The men have always the highest yield, extension advice and ICTs, access to production-enhancing techniques and technologies, quality lands and favourable social and cultural norms (FAO, 2022).

In terms of social burden, the women carry the biggest share such as domestic works, childcare, catering, food for the family, water distribution, health and sanitization management (FAO, 2022). In agricultural labour like any other ones, women and children are in general exploited, forced or mediocre earnings, except their own family one which is not remunerated (Welk et al., 2022; IOM, 2020). In many companies as well as the present systems at the broader women's contributions are undervalued, various unpaid care work (AGRA, 2021). This international institution recognizes that is widely agreed that the efforts from both private and public sector should not be to engage in fitting women into the

current practices or systems but rather to develop gender responsive systems, women friendly ones.

Gender Analysis

Most of gender-based theories are made in contextual frameworks of traditional social scientific providing mainly causal-effect explanation (Scott, 1940). According to the author, this has the drawbacks of limiting understanding the historical trends of the complex social causations as well as biasing the commitments of feminists for better innovative analysis. Gender study should not limit itself to kinship but also modern complex lives such as labour market, education, polity/policy. There is need to include specificity of social organization, cultural representation to better determine substantively constructed gendered identities (Chindarkar, 2012). The approach should not only consider the disparities across the gender but also within it (Bhardwaj, 2021). This is crucial to any gender study since one of the everlasting issues in the field is that gender-neutral factors are more loaded than gender-based or biological ones (Bock, 1989). The author recommended that the gender should be studied in both gender-neutral perspectives and gender-encompassing ones. The latter is qualified as “mixed methods” by Doss and Rubin (2021).

Due to interconnection of gender and sex, the approach should aim at identifying their dimensions regarding the research questions and explicitly operationalize them (IGH, 2023). If in the two past decades, the gender was virtually ignored and the men taken as reference in many studies due to variability and complexity of women, the current research design tends to overlook sex and gender (Heidari, 2016; IGH, 2023). This overview hinders the both the generalizability and applicability of findings in various research and development field for both women and men. Welk et al. (2022) confirmed the outcomes differences noticed by many studies in running intra-household relationships and in-depth analysis. Therefore, gender-disaggregated and sex-disaggregated data analyses are necessary.

There also need for better definition and well-defined measurement methods across gender studies.

METHODOLOGY

Study Area

The study is carried out in Northern region of Ghana located at 640 km from the capital city, Accra. The region is a melting pot of the Mole-Dagbani that is composed of Dagoba, Mamprusi, Gonja, Mossi and other groups of Dagaaba, Kusasi, Sisala, Frafra, Nanumba and Konkomba (Diedong, 2020). They have similarities and share the common identity of “Northness” among their respective communities and societal structures. The population distribution in Northern Ghana is estimated at 7.5% which is the fifth biggest in the country (GSS, 2021). The region has urban-rural share of 47.4% and dispose of the highest growth rate in the country estimated at 3.7%. It also experiences the most shrinking household size during the last decade, which is possibly due to split household and internal and external migrations. This decrease of household size is more noticeable in rural than urban areas, 6 and 4.5 per household respectively. The regional population density is 87.1/km².

The region is an agrarian economy dominated by production of staple food such as maize, groundnut, rice and yam. Despite endemic poverty, the district has great potentiality, dams for irrigation, potentially suitable for livestock production with good breed of cattle, goats and sheep, and inland fishing. It has also potentiality of economic trees such as mango, sheanut, dawadawa or *Adansonia digitata*, soya beans and cotton. The main cash crops in the area are groundnut, maize, millet, guinea corn, cassava, yam and cowpeas (GSS, 2014). The region faces climate shocks such as prolonged dry spells, unpredictable rainfall and food shortage. They are also fragile due to endemic poverty, land related conflicts, and chieftaincy disputes and conflicts.

Sampling Procedure and Data Collection

To elicit the effect of CIS on CSA uses, the study uses the secondary sourced from the survey data collected among the AICCRA intervention communities that are composed of six regions in Ghana. The AICCRA intervention is implemented by CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). It is a decadal program of permanent earlier CIS with three components: village study, organization survey and household survey (Onyango et al., 2012). The database for the present study is driven from the baseline of household survey of 651 units which were selected for data collection in November 2022. For sampling procedure, the program adopted multi-stage sampling where the six regions namely Upper East, Upper West, Northern, Bongo East, Great Accra and Central were purposively selected based on high demographic density, predominance of farming activities and exposure to climate risks. The second stage (specific to the current study) consists of selecting the Northern region due to the urgent need for CSA practices adoption among smallholder farmers to tackle climate-related drawback on farming and livestock systems (FTA, 2020). A sample size of 930 households were selected from the all areas under the IFPRI study, of which 199 were selected from Tolon, Northern region.

Data Analysis

The study first used descriptive statistics. This is necessary since it provides full understanding respondents' socioeconomic characteristics. They also serve as first step in the choice of inferential statistics that fits well the CSA data in hand since they simply describe and summarize the data (Glewwe and Levin, 2023). The study used measures of variability, central tendency and frequency distributions. The measures of central tendency consist of the mean, median and mode while the variability considers minimal and maximal values, range, interquartile range and standard deviation. The frequency distributions will be about organizing and presenting the results on the frequency counts. The results will be presented in form of text, table and figure. Secondly, to determine factors

influencing the adaptation approaches, the study used Ordered Probit Model where the clustered adaptation approaches are used as the dependent variables (DP). These DPs or outcome variables have been already ordered, classified from the most used to the least used and have zero probability of no event (Rifaat and Chin, 2007; Winkelmann, 2015). The confidence level still remains 95% and error term 0.5.

Thirdly, to determine gender inequalities or exposure (practices profitability across gender, and market and non-market benefits), the study used Blinder-Oaxaca decomposition analysis which one the commonest used by gender researchers (Fethi et al., 2023). The model displays the “explained part”, the effects from endowment, composition and quantity, and “unexplained part”, effect of price or discrimination (Jann, 2018). This preferred to other myriad of models usable for gender study due to its simplicity and possibility of incorporating complex survey designs (Jan, 2018; Gujarati and Porter, 2009).

Table 1: Description of variable used in the model

Variable	Description	Measurement	Expected sign
Dependent variable			
CIS Access	If farmers have access to the information	1=Yes; 0=No	+
CSA uses	If farmers use a CSA practice	1=Yes; 0=No	+
Independent variables			
Age	Time from birth to the data of interview of the HHD (number of years)	Year	+
Ethnicity	If the HHD	One among	+

	belongs to ethnic group	others	
Education	Number of years of schooling of the HHD	Years spent in school	+/-
Experience of shocks	Number of years of in farming business of the HHD	Years spent in doing farming	+
Hhd size	Total number of HHD member sharing the same meal/pot	Number	+
Land size	Total surface dedicated to farming	Hectares	+
Asset value	Monetary value of agricultural assets	Currency (Cedi)	+
Distance to the market	Distance to the nearest market	Kilometers	+
Off-farm activity	Dummy=1, for HHD participation to non-farm activity	1=Yes; 0=No	+
Access to credit	Dummy=1, for HHD access agriculture credit	1=Yes; 0=No	+
Distance to extension services	Dummy=1, for HHD access to extension services	1=Yes; 0=No	+
Training	Dummy=1, for HHD participation in training	1=Yes; 0=No	+

Perception	program Multiple choice=1, for HHD perception on CC & CSA use	Scores	+
Profit	Economic gained from CSA	Currency (Cedi)	+
Type 1	Dummy=1, for HHD being elderly female	1=Yes; 0=No	+
Type 2	Dummy=1, for HHD being elderly male	1=Yes; 0=No	+
Type 3	Dummy=1, for HHD being youth female	1=Yes; 0=No	+
Type 4	Dummy=1, for HHD being youth male	1=Yes; 0=No	+

Source: author's compilation, 2024

RESULTS AND DISCUSSION

The “gender” is not explicitly defined by Ghanaian legislation, but the 1992 constitutions and its 1996 Amendment mentioned four categories of gender which can be considered as official ones such as male adult, male young or boy, female adult and young female or girl (PNDC, 1991). The data in hand does not provide household head's age, but rather the primary and secondary respondents' ones. Therefore, the study will used only two categories of gender (male and female) to avoid biased inferential.

Household structures considered in collecting the data for this study are “mixed of male and female”, “solo female adult” and “solo male adult”. The results of descriptive statistics indicate that mixed households dominate among interviewees 91% of which 71% are male headed and 29% are female headed. Among female tenants, 92% of households are of

mixed structure while 8% only are solo. These figures are 90% and 10% respectively among male tenants. This surprisingly higher number of female household headed in a patriarchal society can be explained by two factors all emanating from separation: widows and divorced. The former factor is commonest where the leaves behind the spouse (s) and child or children. The divorced status is quickly solved by another marriage since being single is badly seen by the society. Family union or household is seen one of the most crucial social capital in the Ghana Northern region culture (Marchetta, 2011).

As staple food production, maize production occupies the highest rank with 78% of households involved of which male farmers represent 75% and female 25%. the production of pepper ranks the second highest produced commodity in the area with 11% of which 67% is done by men and 33% by women. Larger family as it is in the Northern region prefer high-yield cash crop or monoculture such maize due to the higher mount of family intake (Acheampong *et al*, 2023). The authors also reported that across Sub-Saharan Africa women have always different preferences and traditional roles in crop production. Some crops are perceived as men's (mostly cereals) and other known as women's such leguminous. Women are also known by their higher involvement in vegetable production.

Among the socio-economic and climate-related shocks, the most experienced by smallholder farmers in the Northern region of Ghana are among others increase in agricultural input prices, extreme weather (mostly dry spell) responsible for poor germination and preventing sowing, decrease in agricultural commodity prices, livestock diseases, crop damage, and post-harvest losses. Among the producers, the prevalence of these shocks are 58%, 44%, 31%, 27%, 26% and 21% respectively. Meanwhile, 12% of households reported losses in human life among members. In recent decades, the human behaviour towards the degradation of the environment and devastation of natural resources have gained new record in all rural sectors, forest-based, agricultural-based, cattle-based and industries. As strike back, the climate is more rude and

smallholder farmers more vulnerable to various shocks (McKeon *et al.*, 2015).

Comparatively, the men and women suffer almost equally from shocks such as extreme weather (mostly dry spell) responsible for poor germination and delay in activities. This finding brings nuance in major findings of many authors such as WBG (2021) and IOM (2019) where women and children are reported as the most suffering of climate-related drawbacks in rural sector. On the other hand, the men suffer at an increasing rate vis-a-vis post-harvest losses with 3%, crop damage with 5%, increase in agricultural input prices with 5%, decrease in agricultural commodity prices with 9%, and livestock diseases with 11% higher than women. These differences can be explained by management of higher number or larger volume of products and herd. Additionally, men may be higher risk-takers compared to women, which sometimes may lead to increased losses in worse scenarios. A similar fact is noticed in livestock management among producers. In general, among small-scale farmers, the higher the volume, the bigger the loss. Tacoli (2011) noticed that women either on-farm or non-farm income generating activities, due to their small assets and power, rarely engaged in risk-taking behaviour, thus making them avoid some loss, but also missing some opportunities.

The strategies adopted by men and women differ in the event of socio-economic or climate-related drawbacks. This is according to their focuses mainly determined by gender roles and responsibilities in the society and particularly in the households. The strategies range from passivism, use of skills, network, culturalism and spirituality, up to financial abstinence. The commonest strategies are displayed in the Table 2 below.

Table 2: Coping strategies (%)

Shock	Percentage of respective coping strategies for men and women						
Extreme weather & drawbacks	Nothing	Cash / Savings	Borrowing	Selling animal	Spirituality	Selling food stock	Extra employment
	44	15	17	9	6	3	-
	57	-	14	7	-	-	21
Crop damage	24	10	33	10	-	-	-
	29	14	43	-	-	14	-
Post-harvest losses	18	18	18	18	-	6	12
	-	-	83	17	-	-	-
decrease in agricultural commodity prices	19	4	23	-	-	-	-
	25	-	13	-	-	13	13
increase	17	7	20	23	-	7	7

in agricult ural input prices,	18	6	47	-	-	6	18
livestoc k diseases , crop damage	57	13	17	9	-	-	-
	17	-	17	17	33	-	-
Loss in human life	22	11	11	-	-	11	-
	33	-	11	-	33	-	-

Source: Author's compilation from IFPRI data, 2024

Unlike any other shocks where half of women take no action, the post-harvest losses engage 83% of women in borrowing money and 17% in selling animals. This may be imputable to the roles of women as food and related resources managers. The household members rely on them at first place and at all the times. Quasi-similarly, women and men both engage in borrowing in the event of crop damage, 43% against 33%. This is because in one hand, men are the first responsible to bring staple food to the household, and on the hand, women not only supplement but they are also responsible for better management. Common engagement in better handling of crop damage is also due to its direct effects on food availability at household level. GeES (2024) recognizes that women and children are more likely to suffer than men since they have limit control over resources and less power relation.

Compared to men, women have higher engagement in borrowing when agricultural input prices increase. This maybe explainable by their

cashless status and requirement for smaller amount of inputs compared to men. In the same direction, women borrowing exceeds men's one, by 11%, in the occurrence of a shock resulting in death of a household member. This is mainly to face the expenses at that moments, funerals, feeding visitors and so on. The WBG (2021) stated that gender-based differences in terms of time load as well as financial and institutional chains women in their social power, decision-making and opportunity to develop.

Women rarely engage in selling food stock or crops. The exception is noticeable in the event of livestock diseases. At less extent, they also hardly engage in selling animals. These two resources are the last recourse for women among their assets. As mentioned above, this is due to their high engagement in food stocks management, on one hand, and animal being the highest symbol of their investments and savings, on the other hand. "Perceived livelihood risks tend to shape individual livelihood strategies" concluded Su *et al.*, (2019) from their research on livelihood risks. Hence, women invest in animals (also living savings) and jewellery as kind to proact certain and uncertain events such as wedding, baptism, climate events, sickness and food insecurity.

Regarding the Climate Information System (CSI), the International Food Policy Research Institute (IFPRI) selected a package of 20 CSI supposed to help in adopting climate Smart Agriculture (CSA) among producers. The results of analysis indicate that CIS access as well as the adoption of CSA are diversely gendered. The most accessible CIS are as follows. the most accessible CIS are "planting time" at 58%, "predicting rainfall" at 52%, "fertilizers application" at 53%, "variety selection" at 44%, and "crop selection" at 43%. The least uptake among the CIS package are "pest and diseases outbreak" at 34%, "soil management" at 33%, "water management" at 32, "drought prediction" at 32%, "cropping calendar" at 28%, "intensity of sun" at 28, "intensity of drought" at 27%, "cloud coverage" at 22%, and "insurance" at 21%.

Women have equal uptake as men regarding crop selection, weed management, water management, and soil management, which are mostly

the least uptake of CIS package. The gender categories slightly differ in access to the CIS of variety selection and cropping calendar by 2% and 3% respectively. The former is more accessed by women while the latter is by men. The highest difference in uptake is observed with CIS of “fertiliser application” where women’s uptake surpasses their fellow men’s one by 20%. In contrast, the men accessed more the CIS of planting time, insurance 7%, pest and disease management, expected amount of rainfall, with differentiae ranging between 7% and 10%. Women despite their unfavourable social rank, roles and responsibility, they have always demonstrated higher uses of extension services (Acheampong *Iet al*, 2023). The authors see this gendered performance as imputable to the efforts of policies and institution to reach larger number of women.

These results show that the uptake of CIS is not only a matter of perception, awareness or proximity but also its contextual relevance to the targeted categories of population. For instance, poorly equipped producers who rely on others mechanized activities such as ploughing will have less interest in calendar, beginning and end time of cropping. Producers are also attempted to seek information about what they believe that their efforts can bring direct or immediate results. For instance, in a rainfed agriculture the CIS of “intensity of sun” or “cloud coverage” may make little sense as does it in irrigated farming. Lastly, a cashless and illiterate producers, dominated by rural women, will little interest in CIS of insurance since the affordability and administrative procedure are seen as challenges. Fagariba and Song (2018) had similar finding about the proactiveness of farmers in making sharp decision regarding climate-related issues.

As well as the incomes are concerned, the IFPRI data build three types of incomes under three weather scenarii: bad condition, good condition and normal condition. The current study makes use only of the normal condition for its simplicity. This income is the sum of incomes generated by different activities undertaken by the household head, male or female. The results of analysis indicate that men earn an annual income of 4881 Ghana Cedi, which is 2.09 times higher than women’s annual income.

Identically, the men have higher yield from the main crop, 1016 tones/ha. This is 1.40 higher than women's yield. These high inequalities find their roots in social, economic and cultural factors in the society. Women producers are ill-equipped for farming activities, their calendar and activities are mainly dependant on others. Added to that, social burden, workloads, household care-taking, children, elderly and sick people may make them have little time for farming activities. Lastly, women's access to quality resources power relation have been ones of the everlasting gender challenges in Ghana (FAO, 2018).

Regarding the climate smart agriculture use, three time-sets are considered: before, during and after the shocks. In total, fifteen practices are considered such intercropping, agroforestry, irrigation, zero tillage, zero residue burning, integrated pest management, drought and stress tolerant seeds, organic manure, biopesticides, contour stone bunds, leguminous crop as previous crop, sticky trap as pest management agricultural insurance, and on/off-farm composting (IFPRI, 2022).

In preliminary test, the Variable Inflation Factor (VIF) conducted on continuous variables had a value of less than 10, with a mean of 1.01. This confirms the absence of multicollinearity. Similarly the results of pairwise correlation show the absence of higher collinearity among the categorical variable except few variables which value equalizes or surpasses 50% (Gujarati and Porter, 2009). Hence, as activity small animal marketing is highly correlated with small animal production, micro-finance association with livestock association, parents and teachers association with village savings and loans associations, and water users' association and shortage of agricultural labour. Producers are divided into three vis-a-vis uses of CSA: weak, medium and high. These are coded 1, 2 and 3 respectively. Ordered Probit was performed followed by marginal effect. The latter offers relatively better interpretation compared to both log odds and odds ratio (Salisu, 2016; Boes and Winklemann, 2004). The model diagnostics show a pseudo-R of 71% and model fitness which is significant at 1%. Therefore, ordered Probit is suitable for the data of the present study.

The results of inferential statistics show that in general the CSA uses are determined by the shocks experienced by farmers more than any other socio-economic, cultural or institutional factors. The shock of “decrease in agricultural product prices” is found to affect the CSA at 1% significant level in different directions among categories 1 and 2 of producers. The prices drop increase the use CSA by categorie-1 while it decreases for categorie-2. The former is attempted to produce more when the prices drop to compensate the lost while the latter may seek for an alternative activities outside agriculture. Kemezi *et al.* (2020) found out that more than have of farmers supplement their revenue from non-farmers activities, relative high risk aversion and and higher attempt for utility maximization.

The shock of “poor quality of agricultural inputs” had similar effect on categorie-1 and 2. that is says, a unit increase of of this shock will increase the use of CSA by a coefficient of 0.186457 in categorie-1 while it will decrease this practice by -.1664998 in categorie-2 as shown in Table 3. The explanation to that maybe imputable to the fact that the categorie-1 or weak users of CSA may seem to be convinced by this technology any time they face a production challenge. Therefore, they are attempted to overcome challenges by using more and more the CSA since it is the best alternative to them. On the other hand, the categorie-2 may see solution farming challenges from another angle. That says, to that class of farmers, solution to any challenge in farming should be solve outside such as by off-farming and less risky activities and , which may reduce dedicated time to agriculture (Kemezi *et al.*, 2020).

The results of analysis show also that the annual income from the farm production affect the use of CSA in the two main categories-1 and 2. One unit increase in total income will increase the use of CSA by 0.0617855 among categorie-2 farmers at 5% significant level. Surprisingly, the opposite effect is observed in categorie-1 where the use decreases by a coefficient of -0.0878757. This latter case may be explained by timid motivation for CSA as well as their interest in investing in farming business among the categorie-1 farmers. In contrast, among the categorie-2 farmers, convinced of the benefit of technologies from their income

generation, any extra income can be a source of more investment farming mostly in a sustainable manner such as CSA uses. Van der Land Hummel (2013) had reported that agriculture as source livelihood is less preferred by many practitioners of the sectors. Added the authors, any extra income is likely invested in non-farm activities for income diversification. On the other hand, farmers are proactive decision-makers whenever they get the means, information and conviction (Fagariba and Song, 2018).

Table 3: Model diagnostics

Model	P-value	Pseudo R ²	AIC	BIC
Ordered probit	1%	77%	55.4346	102.7187
Ordered logit	1%	78%	55.3812	102.6653

Since the ordered logit possesses the smallest AIC and BIC, it is preferred over the ordered probit model (Fabozzi et al., 2014).

Table 4: Ordered logit results for the use of CSA

Variables	dy/dx	Std.Err.
Commodity1_Maize	0.174***	0.032
Commodity2_Pepper	0.168***	0.019
lnglobalincome	-0.116**	0.037
Gender_Female	0.118**	0.051
Shock1_Prevented sowing/poor germination due to drought/extreme weather	0.012	0.025
Shock2_Damage to standing crops	-0.020	0.053
Shock3_Post-harvest crop losses	-0.205**	0.075
Shock4_Drop of sales prices for agricultural produce	0.195***	0.032
Shock5_Poor quality of agricultural inputs	0.158***	0.019
Shock6_Increase in agricultural input prices	0.043	0.034
Shock7_Shortage of agricultural labor	0.113**	0.060
Shock8_Livestock death/disease	-0.149**	0.059
Shock9_Theft (of crops, livestock, etc.)	0.144***	0.016

Shock10_Increase in food prices (increased food expenditures)	-0.041	0.057
Shock11_Illness or injury in the household	-0.085**	0.042
Shock12_Political, religious, tribal conflict	-0.806***	0.022
Shock13_Disease outbreak / pandemic	0.034	0.046
Shock14_Death in the household	-0.050	0.041

NB: *** significance at 1%; ** significance at 5%, and * significance at 10%

CONCLUSION

Northern Ghana is male-headed household dominated area with at around 71%. The composite or mix household (adults male and female) is also the main structure of the households in the region. The agriculture is also dominated by male mainly engaged in maize and pepper production. The commonest socio-economic and climate-related shocks in the area are increase in agricultural input prices, extreme weather (mostly dry spell) responsible for poor germination and preventing sowing, decrease in agricultural commodity prices, livestock diseases, crop damage, and post-harvest losses. Women and men suffer equally in facing extreme weather event at farm level, while the former suffer more regarding other mentioned shocks. The strategies adopted by men and women to tackle the shocks are mainly determined by gender roles and responsibilities. These strategies ranges from passivism, used of skills, network, culturalism and spirituality. These results show that the uptake of CIS is not only a matter of perception, awareness or proximity but also its contextual relevance to the targeted categories of population. Technologies involving cash, high level literacy, heavy and long administrative procedures are of little interests for producers.

The inferential statistics (ordered Probit) showed that in general the CSA uses are determined by the shocks experienced by farmers more than any other socio-economic, cultural or institutional factors. The shock of “decrease in agricultural product prices”, “poor quality of agricultural inputs” and “annual income” are found to be statistically significant and

affect different across the three categories of CSA users: weak, medium and high users.

RECOMMENDATIONS

In ending this research on the “effect of gender-sensitive access to CIS on CSA uses among producers in the staple food supply chain in Northern Ghana”, the following recommendations are formulated:

- ✓ An expansion of the study to other geographical area of the Northern region for better understanding of gender disparities in staple food supply chain.
- ✓ Research should also be conducted on intra disparities or intersectionalities to promote gender-balance intervention along this food supply chain.
- ✓ The efforts should double to make CIS reach wide range of farmers and sensitize on its benefits for sustainable livelihood of the sectors;
- ✓ Special programs should target women in order to improve their assets and access to resources since they have higher responsibility in securing household food security;
- ✓ Avail more financial assistance to staple food producers since the CSA has extra costs compared to conventional practices of agriculture; and
- ✓ Better insurance should also be introduced, and well-designed that is attractive for both insured and insurer.

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ASSESSMENT OF HUNTING ACTIVITIES AND MEAT QUALITY OF GAME IN NORTHERN GHANA

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ABSTRACT

This study was conducted to assess the activities of hunters in the wild, and the techniques employed in harvesting wild animals. The major findings of this study were: (n=200, 52.08%) hunters had over five years hunting experience, however (n=296, 77.08%) hunters had no hunting background, (n=200, 52.1%) hunters goes to hunting sites using vehicles, only (n=378, 98.4%) of hunters get animals to exsanguinate during hunting, (n =94,47%) hunters hunt wild animals using clubs/dogs, (n=372, 96.88%) hunters carry their kills in bags/sacks, (n=202, 52.6%) hunters clean their hunting wears on weekly basis, (n=340, 88.5%) hunters clean or sterilize their hunting devices, (n=378, 98.4%) hunters takes up hunting expeditions during daytime and (n=192,96%) hunters do not process the animals they killed before sending them home, (n=374, 97.4%) hunters had no knowledge on animal welfare issues and (n=9, 4.5%) hunters burned the bush to flush out game to hunt them, some hunters (n=6, 1.56%) hunted wild animals using poison. The study also revealed that majority of hunters (n=312, 81.25%) dug burrows to capture hidden animals, especially rodents. Some hunters though not in majority (n=30, 7.81%) were engaged in bush burning in other to chase out hidden game to hunt. It was also revealed that daytime hunters (n=378, 98.44%) were more than night hunters (n=6, 1.56%) and most hunting activities were done during the dry season. Finally, the commonest animals hunted for meat were rats (n=1137, 49.5%), followed by quails (n=363, 15.7%) and rabbit (n=264, 11.5%) with the least been monkeys (n=15, 0.7%)

Keywords: Hunting, Bush meat mongers, processing techniques, preservation, frying.

INTRODUCTION

Human consumption of meat goes way back as far as man can remember. Man hunted animals for meat at the time when there was no equipment for really hunting expeditions. As hunter-gatherers, humans may have competed for prey with large predators (Graham et al., 2005), resulting in the deliberate targeting of these by humans (Shipman, 2015). Subsequently, the transition to agriculture created greater motives for the control of native wild animals, as well as their hunting for animal protein (Lee and De Vore, 2017). Brashares et al., (2001) suggests that bush meat hunting has contributed to the rapid decline in population of 41 mammal species since the 1970s. Hunters in northern parts of Ghana has contributed to both air and water pollutions, thus making aquatic life unfavorable and deadly (FAO, 2011). Milner-Gulland and Bennett, (2003) reported that although humans have hunted wildlife for over 100,000 years, consumption has increased considerably over the past few decades. Recent reports estimate that wild meat harvest in Central Africa is now in the order of 3.4 million tons per annum (Fa et al., 2001). In the Congo Basin it is estimated that hunting typically contributes between 30-80% of protein consumed by forest dwelling households (Koppert et al. 1996). However, recent evidence from Western Africa suggests that households have become increasingly more commercially oriented, with hunting acting as an important source of income (Kumpel, 2006, De Merode et al. 2004).

De Merode et al. (2003) estimated that in the DRC more than 90% of the harvested fish and bush meat is sold rather than consumed by hunters. Similarly in Ghana where wild foods are reported to still consist of a large proportion of household level production, most bush meat is not consumed by hunters but sold to the markets (Cowlshaw et al. 2004; De Merode et al. 2003; Solly, 2004) both in Cameroon and DRC respectively found similar evidence that bush meat hunting was an important safety net to obtain small but regular income during the lean agricultural season. It still

however remains unclear to what degree household economies may benefit from bush meat compared to other income sources or food economies (Davies and Brown, 2007). However, since the mid-1970s, the animal rights lobby has intensified and especially against recreational hunting (Nurse, 2013). Given the situation stated, there is an urgent need for more measured debates and better understanding of people's perceptions of legitimate and illegitimate killing of wildlife, as well as the role of cultural traditions in explaining the different views (Caro et al. 2017; Pardo & Prato, 2005). In this study, we analyzed the activities of hunters during hunting and their hunting techniques in northern Ghana.

MATERIALS AND METHODS

Study Location: The study was conducted in some selected hunting communities in northern Ghana (Dabogshee, Tantuyani, Chamba, Lantinkpa, Sakpalua, Binjaaya, Deba, Kpunchila, Waribogu and Wulugu). According to the 2010 population and Housing Census (PHC) the total population of Northern Ghana was 4,228,116 representing 17.1% (Ghana Statistical service, 2010). Out of this, the Northern Region (that is, current northern region, north-east region and savanna region) had a population of 2,479,461 people representing 10.1% of the total population of northern Ghana. Northern Ghana's geographical boundaries include: the Upper East and Upper West Regions to the north, the Brong Ahafo and Volta Regions to the south, and the neighboring countries of Burkina Faso to the north, Togo to the east, and Cote d'Ivoire to the west. Mapped location of Northern Ghana (N 9° 30' 0", E -1° 0' 0"). The study areas experiences one rainfall season annually beginning in May and ending in September. The average annual rainfall in northern Ghana falls within the range of 750 to 1050 millimeters (30 to 40 inches). The wet season typically runs from April to October, while the dry season occurs from January to March. The average temperature is 31°C with a minimum of 28.2°C and a maximum of 34°C (SARI, 2008). The vegetation of this area consists of grassland sparsely dotted with small drought resistant trees. The major

occupation of inhabitants of the region is agriculture with few people involved in trading.

Study Population: For the purpose of this research study, the target populations were hunters, hunting in ten (10) selected hunting communities. The communities includes; Dabogshee, Tantuyani, Chamba, Lantinkpa, Sakpalua, Binjaaya, Deba, Kpunchila, Waribogu and Wulugu

Sampling Technique and Sample size: Purposive sampling technique was used to select the ten hunting communities based on frequent hunting activities in the areas.

Also, simple random sampling was used to obtain sample size for the hunters using the standard formula.

Sample size calculation:

Standard Formula for Sample Size (for large or unknown population)

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

Where:

- **n** = required sample size
- **Z** = Z-value (standard score corresponding to the desired confidence level)
 - e.g., 1.96 for 95% confidence, 2.58 for 99%, 1.64 for 90%
- **p** = estimated proportion of the population (use 0.5 if unknown — it gives the most conservative/maximum sample size)
- **e** = margin of error (commonly 0.05 or 5%)

Let's plug in:

$$Z = 1.96$$

$$p = 0.5$$

$$e = 0.05$$

$$\begin{aligned} n &= \frac{Z^2 * p * (1 - p)}{e^2} \\ n &= \frac{(1.96)^2 * 0.5 * (1 - 0.5)}{(0.05)^2} \\ n &= \frac{3.8416 * 0.25}{0.0025} \\ n &= \frac{0.9604}{0.0025} \\ n &= 384.16 \\ n &\approx 384 \end{aligned}$$

Three hundred and eighty four (384) copies of semi-structured questionnaires were randomly administered to 384 respondents with 38 questionnaires each in nine (9) hunting sites and 42 in one hunting site

Data Collection: The primary sample unit in this study were hunters. Ten hunting sites were purposively sampled during the 2025 illegal hunting period. Data on hunters were obtained through interviews using the interview guide. Visitation to hunter heads were preceded the interviews to request permission for research activities. After the first visit, each hunting site was visited at least twice and a minimum of 10 minutes was spent to survey one hunter. Oral consent was sought from hunters' heads prior to the commencement of the survey with options to opt out at any stage of the survey. Primary data were collected using a semi-structured questionnaire (direct questioning) with closed-ended questions. These were designed, piloted and administered in the face to face survey of hunters. The survey was conducted in Dagbani language with interpretations in the English language where necessary.

Data analysis

In analyzing the data collected, the responses were classified and coded on the basis of the information provided by the respondents. Descriptive statistics such as, tabular description and summary statistics like percentages and frequencies were used to analyze the quantitative data. The qualitative data was analyzed using themes (thematic analysis).

RESULTS

Table 1: Socio-Demographic Characteristics of Hunters

Background Characteristics	Frequency	Percent
<i>Educational Studies</i>		
Primary	108	28.13
Secondary	100	26.04
Tertiary	32	8.33
None	144	37.50

Religion

ATR	11	2.86
Islam	351	91.41
Christianity	3	0.78
None	19	4.95

Source: Field Survey, 2024

Table 2: Background knowledge of hunters on hunting

Criteria	Frequency	Percent
Response of hunters on how long they have been hunting game		
Less than a year	4.0	1.04
1-2 years	80.0	20.83
3-5 years	100	26.04
Over 5 years	200	52.08
Responses of hunters on if they have a hunting background		
Yes	88.0	22.92
No	296.0	77.08
Responses of hunters on if they ever undergone any training on hunting		
Yes	4.0	1.04
No	280	98.96
Response of hunters on if they have knowledge on animal welfare		
Yes	84.0	21.88
No	300	78.12
Response of hunters on the season they go for hunting game		
Dry season	292	76.04
Wet season	84.0	21.88
All year round	8.0	2.08

Source: Field Survey, 2024

Table 3: Techniques employed by hunters during hunting

Criteria	Frequency	Percent
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Response of hunters on devices they hunt wild animals with		
Using traps/snares	20.0	5.21
Using guns	90.0	23.44
Using bow and arrow	70.0	18.23
Using animals/Clubs	204	53.12
Responses of hunters on if they use poison in hunting wild animals		
Yes	6.0	1.56
No	378	98.44
Response of hunters on if they burn the bush to capture wild animals		
Yes	30.0	7.81
No	354	92.19
Responses of hunters on whether they make burrows or not to capture animals		
Yes	312	81.25
No	72	18.75

Source: Field Survey, 2024

Table 4: General activities of hunters affecting meat quality

Criteria	Frequency	Percent
Responses of hunters on whether they exsanguinate animals during hunting		
Yes	362	94.27
No	4.0	1.04
Sometimes	18.0	4.69
Responses of hunters on whether they process the animals they kill in the wild		
Yes	20.0	5.21
No	358	93.23
Sometimes	6.0	1.56
Hunters responses on how they carry/handle carcasses during hunting		
By carrying them in bags/sacks	372	96.88

By hanging them under their armpits	8.0	2.08
By carrying them on their heads	4.0	1.04

Source: Field Survey, 2024

Table 5: Shows hunting devices and number of hunters who used it during hunting

Hunting equipment/items Percent (%)	Number of hunters who used it	
Dogs/guns/clubs	306	79.69
Traps/guns	10	2.60
Guns/clubs	45	11.72
Chemicals/poison	2	0.52
Clubs/bow and arrow	3	0.78
Dogs/clubs	18	4.69
Total	384	100

Source: Field Survey, 2024

Pictures of some hunters and hunting devices





Table 6: Total number of wild animals most hunted for meat with percentages

Animals (%)	Number	Percent
Rabbit	264	11.5
Squirrel	202	8.8
Guinea Fowl	237	10.3
Quails	363	15.7
Antelope	19	0.8
Rats	1137	49.5
Snakes	22	1.0
Monkeys	15	0.7
Grass cutter	39	1.7
Total	2,298	100

Source: Field Survey, 2024

Pictures of some killed wild animals



DISCUSSIONS

Background Characteristics of Hunters

Educational status

The educational status revealed that hunters who had no form of education were majority (37.50%), followed by hunters who had primary education (28.13%). Hunters with secondary education (26.04%) were third with tertiary education (8.33%) been the least amongst the hunters.

Religion

The religion of hunters revealed that majority of hunters (91.41%) were Muslims, followed by hunters (4.95%) who had no religion. Hunters (2.86%) who practiced African Traditional Religion were third and Christians been the least number (0.78%) of hunters.

Responses of hunters on if they have a hunting background

The responses of hunters should that they majority of hunters (77.08%) had no hunting background. This confirms the findings of (Douglas et al., 2007) who reported that the number of years that a household has been involved with hunting in Ashanti region is generally low. However, eighty eight (88) hunters representing (22.92%) indicated that they hunted wild animals with their grandfathers and their fathers before they also became hunters. This agrees with the report of Herberlein et al., (2002) who indicated that people living or growing up in rural areas, who have at least one parent who hunts, hunt more often than others.

Responses of hunters on how long they have been hunting game for

The study revealed that hunters who had less than one year hunting experience were the least (1.04%) amongst the hunters, followed by hunters (20.83%) who had less than two years hunting experience. Hunters with 3-5 years hunting experience had (26.04%) and those with over 5 years hunting experience been the majority (52.08%) as shown in table 2.

Hunters' responses on how long they stay in the wild during hunting

Out of the two hundred (200) hunters interviewed, three hundred and seven (307) hunters representing 79.95% stated that they spent the entire day hunting for wild meat. This agrees with the findings of FAO (2000) who indicated that night hunters leave their homes after dark for the forest and normally hunts until day break before returning home. Also, seventy three (73) hunters representing 19.01% indicated that they hunt for animals for half a day. Four (4) hunters representing 1.04% opined that they hunt animals for less than six hours a day. Averagely, hunters spent seven hours in the bush during hunting (Adongo et al. 2012). FAO (2000) also reported that a hunter or two to three hunters in a group may camp out in the forest to hunt and would remain in the forest for periods ranging from a few days to a couple of weeks.

Hunting devices/tools used by hunters during hunting

A variety of equipment and devices were used to kill or capture wild animals, depending on many factors such as characteristics and behavior of the species, habitat requirements of the species, traditional background of the hunters as well as the security of the hunting locality (Bennet & Robinson, 2000; FAO, 2000; Bakarr et al. (2001). Responses of hunters interviewed revealed that ninety four (94) hunters representing 47% use trained dogs and clubs to hunt wild animals, eighty (80) hunters representing 40% revealed that they hunt game using guns. Laatung et al. (2019) revealed that several methods and tools are used for hunting rats in Minahasa, but the most widely used is a gun. Molade (2000) noted that most urban professional hunters use rifles and other licensed automatic weapons in hunting wild animals.

Time of the day hunters go for hunting game

Based on the results of the study, it was revealed that majority (378) of hunters representing 98.44% hunted wild animals during the day time. The reason for this majority could be that most of the hunters were young and had official jobs or own their own businesses. Few (6) hunters representing 1.56% were night hunters. The night hunters asserted that they get better kills in the night than in the day time. This confirms the findings of (FAO, 2000) who reported that though illegal in many countries, night hunting is very common and very popular among professional hunters since the success rate is much higher.

Season hunters go for hunting wild animals

Sixty-nine (69) hunters representing 17.97% stated that they hunt wild animals all year round. This confirms the findings of Adongo et al. (2012) who indicated that in southern Ghana, hunting is done almost all year round either individually or in small groups. Seventeen hunters (17) representing 4.43% stated that they hunt alone during the wet season. This agrees with the findings of FAO (2000) who revealed that night hunting is mostly a solitary affair, although some hunters would use an assistant, a

helper or someone to carry the kill. A single hunter or two to three hunters in a group may also camp out in the forest to hunt and would remain in the forest for periods ranging from a few days to a couple of weeks (FAO, 2000). It was also found that majority of hunters (298) representing 77.6% hunted wild animals during dry season. This affirms the report of Adongo et al., (2012) who revealed that hunting in northern parts of Ghana is confined only to the dry season months (from November to April).

Responses of hunters on knowledge on animal welfare

The manner in which meat is produced has been a growing concern for consumers, which considers environmental, social, ethical, and animal welfare aspects (Alonso et al., 2020; Teixeira & Rodrigues, 2021). Out of 384 hunters interviewed, three hundred (300) hunters representing (78.12%) indicated that they had no knowledge on animal welfare. Estevez-Morino et al. (2021) opined that the importance of animal welfare for consumers' perception of meat and meat products varies according to gender, rural or urban origin, educational level, and age. Garcia-Gudino et al. (2021) found that consumers show a remarkable preference for Iberian pork products, mainly when the animals are reared freely and in natural conditions, giving great importance to animal welfare. However, eighty four (84) hunters representing 21.88% had no knowledge on animal welfare.

Responses of hunters on if they have ever undergone any training on hunting

The study revealed that majority of hunters (380) representing 98.96% has never had training on animal hunting. However, four (4) hunters representing 1.04% indicated they have attended a training on hunting organized by Ministry of Food and Agriculture (MoFA).

Hunters' responses on how they carry hunted animals during hunting

The study revealed that majority of hunters (372) representing (96.88%) carry their kills in bags and sacks. FAO (2000) reported that night hunting is mostly a solitary affair although some hunters would use an assistant, a helper or someone to carry the kills. A group of hunters (8.0) representing 2.08% stated that they carry their kills by tying them under their armpits. Few hunters (4) representing (1.04%) carry their kills on their heads and drag big-size animals like deer, hedgehogs affecting meat quality. Zulkifli et al., 2014; Agbeniga & Webb, (2012) reported that the way in which animals are handled, restrained and slaughtered can affect their welfare and the quality of the meat.

Response of hunters on whether they use poison in hunting wild animals

It was found from the study that six (6) hunters representing 1.56% indicated that they used poison to hunt wild animals. Espana (2007a) reported that the use of poison for hunting and fishing is a criminal offence punishable by law in Spain, due to its impact on the species conservation and its massive and non-selective character. De la Bodega et al., (2020) confirmed that poisoning is considered one of the main causes of mortality in the wild. However, majority of hunters representing 98.44% employed other hunting devices during hunting.

How often hunters clean/sterilizes their hunting devices

Equipment and devices used for hunting wild animals needs to be disinfected or sterilize after each use. The study revealed that one hundred and fifty (150) hunters representing 39.0% had never sterilize their hunting devices. One hundred and ninety eight (198) hunters representing 51.56% clean their hunting devices weekly, twenty six (26) hunters representing 6.77% cleaned their hunting equipment when they get the chance and ten (10) hunters representing 2.6% cleaned their hunting daily. Various alternatives with an equivalent effect to hot-water treatment and

combinations of hot water with chemicals have been evaluated for knife decontamination in the meat industry (Barbosa et al., 2016; Brasil et al., 2017; Taormina & Dorsa, 2007). Ultra-violet (UV) light is commonly used in the food industry for the decontamination of surfaces (e.g., packaging material), water, or air (Bintsis et al., 2000) and it could constitute a promising, non-thermal alternative for knife decontamination. Also, twenty six (26) hunters revealed that they clean their hunting devices whenever they get the chance to do so. However, one hundred and fifty (150) hunters indicated that they have never clean or sterilize their hunting devices. This goes contrary to the view of Reij et al. (2003) who indicated that animal slaughtering equipment (knives and arrows) should be sanitized between each use to reduce cross-contamination areas.

Responses of hunters on if they exsanguinate hunted animals

The study revealed that majority (362) of hunters representing (94.27%) exsanguinated killed animals using knives. Anil et al., (1995a,b) indicated that sharpness of the knife and performing a complete uninterrupted cut could influence other factors such as vasoconstriction, clotting, ballooning also known as carotid occlusion, or false aneurisms. Four (4) hunters representing 1.04% did not get animals to exsanguinate. To optimize bleed out at slaughter and reduce carcass and meat processing industry, as improved bleeding can improve the quality of the meat during storage (Ali et al., 2007). However, eighteen (18) hunters representing 4.69% indicated they sometimes get animals to bleed. The lack of bleeding can promote meat spoilage as blood is an excellent medium for bacteria and other microscopic organisms. Lerner (2009) confirmed that blood favours multiplication of spoilage microorganisms and acts as a carrier for food borne pathogens.

Responses of hunters on animal processing in the wild

It was found that majority of hunters (358) representing 93.23% did not process the carcasses before taking them home. This affirms the findings of FAO (2000) who revealed that it is common for animals killed on night

hunting trips to be kept till day break before the hunters sets off for the market center, which means animals often get to the markets several hours after been killed. Twenty (20) hunters representing 5.21% confirmed that they process the carcasses they kill for meat. This affirms the findings of Adongo et al. (2012) who reported that some hunters take the chance during break periods to dress the animals they have killed at the roadside using fire while waiting to be conveyed back to their locality. Also, six (6) hunters representing 1.56% stated that they sometimes processed the carcasses of animals they harvested.



Response of hunters on if they have ever burn the bush to flash out game during hunting

The study revealed that three hundred and ninety (319) hunters representing 83.07% opined that they have burnt the bush in some cases in order to ease their chase for hidden game and also to flash out animals hidden in burrows. This confirms the findings of (FAO, 2000) which indicated that a group of hunters in smaller groups set bushes on fire and animals are killed with cutlasses and clubs as they run out of the area to escape the fire. The use of fire in group hunting is more common in the grassland savannah areas (Adongo et al. 2012). A group of rat hunters would search for rat holes and set fire at the entrance using dry leaves. The

smoke penetrates the burrow and forces the rat to come out while the hunters would be waiting at vantage points around the holes ready to kill the rats as soon as they come out (Adongo et al. 2012). However, sixty five (65) hunters representing 16.93% indicated that they have never burnt the bush to flush out wild animals.

Responses of hunters on if they make burrows to capture wild animals

The responses of hunters indicated that majority of hunters (312) representing (81.25%) dug burrows during hunting to capture animals. Some animal species especially rodents and reptiles make burrows for their safety and that of their young ones. This is confirmed by the report of Haussman (2017) who reported that terrestrial and aquatic species excavate burrows for defensive, reproductive, or refuge purposes. Dixon et al., (2009) reported that the most studied burrowing vertebrates are mole rats. Seventy two (72) hunters representing 18.75% did not make burrows during hunting.

Hunters' responses on how often they wash or clean their hunting regalia

The findings of this study revealed that two hundred and eighty three (283) hunters representing 73.7% indicated that they wash their hunting wears whenever they deem it necessary. Sixty one (61) hunters representing 15.89% cleaned their hunting wears weekly, five (5) hunters representing 1.3% cleaned their wears on daily basis. However, thirty five (35) hunters representing 9.11% never clean their hunting wears. For meat to be produced wholesome, personnel involved in killing and processing animals should observe personal hygiene. Hunters with clean hands, clothing and good hygienic practices are absolutely essential to the production of high-quality foods. This affirms (Ofosu-Koranteng, 2010) who reported that personnel involved directly with meat processing and handling should not wear unhealthy cloths such as aprons, hand gloves and shoes.

Hunters' responses on whether they have been licensed by the forestry commission of Ghana

The study found that both day and night hunters from the study areas were not licensed (n=384, 100%) by the forestry commission. It is the mandate of the commission to protect and preserve both the forest and wild animal species in the forest. The Commission also issues licenses to hunters, and permits to market women before they could sell bush meat. Literature revealed that hunters from some parts of Ghana especially those from southern part has been licensed by the forestry commission before they can hunt some species of wild animals. Acquah (2013) revealed that people can acquire a license from the Wildlife Division and hunt grass cutters and other wild animals outside parks and reserves as bush meat.

Wild animals most hunted for meat in northern Ghana

In the study areas, the commonest animals that were hunted for meat were rabbits, squirrels, quails, guinea fowls and rats. This was seen among hunters, as majority of them had rabbits among their kills. Also, in the wild meat market, majority of bush meat sellers had more of rabbit meat among the meat they were selling to consumers. Animals such as snakes, bats, bushbucks, wild cats, grass cutters and some species of wild birds were also hunted for meat.

CONCLUSIONS

Hunting techniques identified were considered eco-friendly except few hunters who used poisons, gunpowder and bush burning which are considered threat to human health and the environment. Generally, carcass handling of hunters were good as majority of them bagged their kills. However, there is room for improvement. The commonest animals killed for meat were rats, rabbits, quails and guinea fowls which are all considered delicacies for the people of northern Ghana.

RECOMMENDATIONS

The following recommendations were made by the researcher:

1. Hunters should be registered by registrar general and hunting laws enforced by the forestry commission.

2. In-service training should be organized for hunters periodically by officials from the forestry commission
3. Hunters must be regulated by the forestry commission on the number of animals to kill per a hunting episode
4. Measures should be put in place by the forestry commission in order to completely ban hunting in northern Ghana as it leads to the extinction of some wild animal species

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SOME SELECTED PICTURES FROM THE AIC ALBUM







