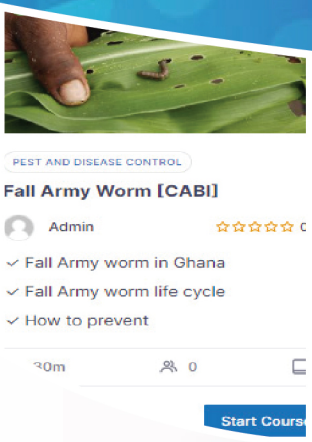
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

INSTITUTE FOR SCIENTIFIC AND TECHNOLOGICAL INFORMATION RESEARCH

CSIR-INSTI



Annual Report 2023

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INSTITUTE FOR SCIENTIFIC AND TECHNOLOGICAL INFORMATION

(CSIR-INSTI)

2023 ANNUAL REPORT

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List Of Acronyms & Abbreviations

AAG	-	American Association of Geographers
ACO	-	Ant Colony Optimization
AGM	-	Annual General Meeting
AGORA	-	Access to Global Online Research in Agriculture
AI	-	Artificial Intelligence
AIDS	-	Acquired Immunodeficiency Syndrome
AJOL	-	African Journals Online
AMA	-	Accra Metropolitan Assembly
ARI	-	Animal Research Institute
AUDA-NEPAD	-	African Union Development Agency - New Partnership for Africa's Development
AWS	-	Amazon Web Service
BRRI	-	Building and Road Research Institute
CABI	-	Centre for Agriculture and Bioscience International
CCST	-	CSIR College of Science and Technology
CGAIR	-	Consultative Group on International Agricultural Research
CIAT	-	International Centre for Tropical Agriculture
CLIMACCESS	-	Climate Change Resilience in Urban Mobility
CNN	-	Convolutional Neural Networks
CRI	-	Crop Research Institute
CSIR	-	Council for Scientific and Industrial Research
DOAJ	-	Directory of Open Access Journals
DRB	-	Densu River Basin
EBSCO	-	Elton Bryson Stephens Company
EIA	-	Excellence In Agronomy

FAR	-	Fixed Assets Register
FAIR	-	Findable, Accessible, Interoperable and Reusable
FAO	-	Food and Agriculture Organisation
FARA	-	Forum for Agricultural Research in Africa
FORIG	-	Forestry Research Institute of Ghana
FRI	-	Food Research Institute
FPGAs	-	Field Programmable Gate Arrays
FSRP	-	Food Systems Resilience Programme
GDP	-	Gross Domestic Product
GAIP	-	Ghana Agricultural Insurance Programme
GHANEPS	-	Ghana Electronic Procurement System
GIS	-	Geographic Information System
GISD	-	Geospatial and Information Science Division
GISS	-	Geographic Information Systems Section
GJAS	-	Ghana Journal of Agricultural Science
GJS	-	Ghana Journal of Science
GPS	-	Global Position Systems
GPUs	-	Graphics Processing Units
HINARI	-	Health Inter-Network Access to Research Initiative
HIV	-	Human Immunodeficiency Virus
HTML	-	Hypertext Markup Language
ICT	-	Information and Communication Technology
IDE	-	Integrated development environment
IEEE	-	Institute of Electrical and Electronic Engineers
IITA	-	International Institute of Tropical Agriculture
INSTI	-	Institute for Scientific and Technological Information
IoT	-	Internet of Things

ITS	-	Intelligent Transport Systems
JPEG	-	Joint Photographic Experts Group
JSTOR	-	Journal Storage
KNUST	-	Kwame Nkrumah University of Science and Technology
LiDAR	-	Light Detection and Ranging
MAG	-	Modernising Agriculture in Ghana
MATLAB	-	Matrix Laboratory.
MCU	-	Microcontroller Unit
MGQS	-	Mirza Ghulam Qadir Shaheed
ML	-	Machine learning
NADMO	-	National Disaster Management Organisation
NGO	-	Non-Governmental Organisation
OARE	-	Online Access to Research in the Environment
OPRI	-	Oil Palm Research Institute
PGRRI	-	Plant Genetic Resources Research Institute
PLS	-	Physical Layer Security
PNAS	-	Proceedings of the National Academy of Sciences
REST	-	Representational State Transfer
RRN	-	Recurrent Neural Networks
RTA	-	Road Traffic Accidents
RTL	-	Register Transfer Level
S&T	-	Science and Technology
SARI	-	Savanna Agricultural Research Institute
SDG	-	Sustainable Development Goals
SDI	-	Selective Dissemination of Information
SDR	-	Software-Defined Radio
SIMS	-	Scientific Information Management Section

SMART	-	Specific Measurable Attainable Reliable and Time-bound
SMEs	-	Small and Medium Enterprises
SoC	-	System-on-Chip
SQL	-	Structured Query Language
SRI	-	Soil Research Institute
STEPRI	-	Science and Technology Policy Research Institute
STI	-	Science and Technology Innovation
TEEAL	-	The Essential Electronic Agricultural Library
TOGAF	-	The Open group Architecture Forum
UAV	-	Unmanned Aerial Vehicles
UESD	-	University of Environment and Sustainable Development
USGS	-	United States Geological Survey
UX	-	User Experience
WP	-	Work Packages
WRI	-	Water Research Institute

2023 Management Board Membership

Prof. Abdulai Mohammed-Sani	-	**Chairman**	Associate Professor and Consultant, African Centre for Development Informatics, Accra
Dr. Seth Awuku Manteaw	-	**Member**	Director, CSIR-INSTI
Dr. Mrs. Wilhemina Quaye	-	**Member**	Director, CSIR-STEPRI, Cognate Director, CSIR-INSTI
Mrs. Genevieve Yankey	-	**Member**	Representative of Director-General, Director of Administration, CSIR
Mr. Emmanuel Amoh	-	**Member**	Printing Expert
Mr. Benjamin Abugri	-	**Member**	Knowledge Manager, FARA
Prof. Dr. Ing. Ezer Osei Yeboah-Boateng	-	**Member**	Telecoms Engineer
Mrs. Dorothy Awanyo	-	**Secretary**	Head of Administration, CSIR-INSTI

2023 Internal Management Committee Membership

Dr. Seth Awuku Manteaw	-	**Chairman**	Director
Mr. Benjamin Y. Folitse	-	**Member**	Deputy Director
Dr. Albert N.M. Allotey	-	**Member**	Head of Geospatial & Information Sc.
Mrs. Dorothy Awanyo	-	**Member**	Head of Administration
Dr. Paul A. Danquah	-	**Member**	Head of Communications
Dr. Agnes Decardi-Nelson	-	**Member**	Head of Printing & Publishing Science Division/ President of Research Staff Association (local)
Ing. Michael Wilson	-	**Member**	Head of Electronics
Mr. Mohammed N. Zainudeen	-	**Member**	Ag. Head of Fluid Science
Mr. Stephen Kwaku Asante	-	**Member**	Head of Accounts
Mr. William Akpakli	-	**Member**	President of Senior Staff Association (local)
Mr. Eric Acquaye	-	**Member**	Chairman of Trade Union Congress (local)
In Attendance			
Ms. Esther Opoku	-	**Secretary**	Administrative Officer

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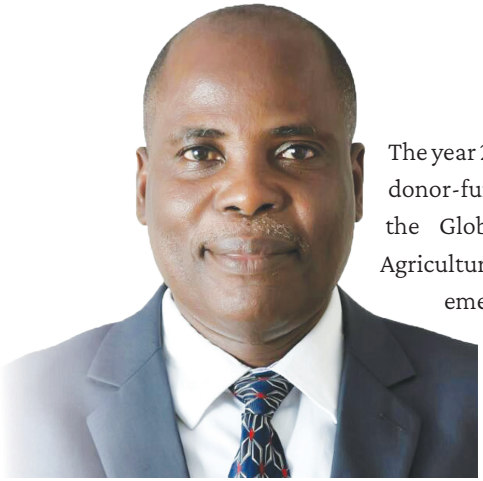

Dr. Seth Awuku Manteaw
Director, CSIR-INSTI

FOREWORD

The year 2023 witnessed the completion of two flagship donor-funded projects of the Institute. The first was the Global-Affairs-Canada sponsored Modernising Agriculture in Ghana (MAG) programme, out of which emerged five digital solutions for agricultural extension delivery in Ghana, namely the CSIR Kuafo Marketplace, CSIR Agritech Advisor, CSIR Technologies Portal, CSIR Management Repository and the CSIR Farm Academy. These digital solutions have all been deployed and are expected to modernise agricultural extension and advisory service delivery to Ghanaian farmers, processors, marketers and other actors in the Agricultural Commodity value chains. The second flagship project completed was the Danish-Government-Sponsored Climate Change Resilience in Urban Mobility designed to develop research-based strategies to enhance accessibility and transport in Accra by examining sectors determining resilience to climate change impacts. The outputs of the project have immense benefits to emergency service providers such as the Ghana Fire Service, Ghana Ambulance Service, National Disaster Management Organisation and planning officers within the various Metropolitan, Municipal and District Assemblies. The Institute continued its partnership with such private sector and development partner entities through the implementation of projects/programmes such as Grow with Google Scholarship Programme, the Excellence in Agronomy Project and the Ghana Agricultural Data hub.The implementation of these projects is consistent with the mandate of CSIR-INSTI, and offers the opportunity for the Institute to leverage its technological accomplishment, especially in the digital space. Divisions of the Institute continued with their various research and development projects, evidence of which can be seen in the various publications by scientists of the Institute.

The year 2023 has been fulfilling, Management and staff are grateful to the Government of Ghana, development partners and friends of the Institute for the support in carrying out the Institutes mandate. It is the honour and pleasure to present the 2023 Annual Report of CSIR-INSTI. Thank you.

EXECUTIVE SUMMARY

In fulfilment of the mandate of the Institute in the year 2023, some research projects, programmes and initiatives were carried out in collaboration with some sister research institutions, private sector organisations, and development partners. The following sections provide a summary of these projects.

Grow With Google Scholarship Programme/ Consultancy Project: The project aims to recruit low-income citizens between the ages of 18 to 35 in the Greater Accra Region for the award of professional certificates on Coursera platform through in-person and virtual assistance, career coaching, mentorship sessions, and internships. Boot camps and mentoring sessions were organised, and cash prices given, leading to an increase in relevant course completion.

Excellence in Agronomy Project: The project focused on creating agro-advisory tools and a mobile app to guide farmers and extension officers all-year round, considering region-specific parameters and crop types in specific geographical areas. As a result, agro-advisory tools, including a digital cropping calendar, were developed and a technical implementation process had also been initiated. This mobile-compatible web app offers tailored guidance, optimises resource use, increases productivity, and aids in decision-making.

Ghana Agricultural Data Hub (AG-Data Hub): The project aims to support data migration into FAIR formats, to engineer a seamless data flow architecture, implement APIs for data gaps bridging, and facilitate the development of decision support systems and dashboards.

CSIR SOFTLAB: This initiative aims to leverage the Mirza Ghulam Qadir Shaheed I.T Research Lab & Centre's expertise to establish a leading software testing facility in Ghana to set industry standards for software deployment and contribute to the country's software industry growth. The facility will train staff for International Software Testing Qualifications Board Certifications, offer commercial software testing services for SMEs, and provide free software testing services for Ghanaian University students.

MAG 2023 Deliverables: The Modernising Agriculture in Ghana (MAG) Programme focused on developing platforms to consolidate all developed agricultural technologies and enhance training. As part of the implementation of the Programme, an e-learning platform (CSIR Farm Academy) with video content in local languages was developed to disseminate agricultural and technological information and provide education on best practices across various value chains.

Climate Change Resilience in Urban Mobility: This project developed research-based strategies to enhance climate change resilience in urban mobility, accessibility, and transport in Accra by examining factors determining resilience to climate change impacts. The study found flood hotspots in Adentan, Glefe, Pokuase, and Santa Maria, with 20% of access routes to these hotspots having obstacles. The project has benefited Emergency Service providers such as the Ghana Fire Service, Ghana Ambulance Service, National Disaster Management Organisation (NADMO), and Planning officers within various district, municipal and metropolitan assemblies.

Changes in Ecosystem Services in Riparian Forests: The project assessed the changes in ecosystem functions of the Densu River Catchment over 30 years to establish the underlying causes of the changes. The study revealed that land use and land cover changes in riparian areas had led to declines in ecosystem services, hence there was the need for sustainable agricultural practices to prevent rapid conversion of forest land to agricultural lands. These findings would enhance environmental monitoring in the Densu basin and assist various municipal, metropolitan, and district assemblies in managing their activities.

Dissemination Pathways for Scientific Research Findings: The study identified factors affecting the dissemination of research outputs by CSIR scientists to evaluate the strengths and control of research dissemination pathways within the information dissemination ecosystem. Data collection is currently ongoing for further analysis.

Printing Services: The Institute designed and printed S&T branded materials such as Annual Reports, Magazines, Manuals, Calendars, Forms, and Books for sister Institutes of the CSIR, the Head Office, and other external organisations.

Information Dissemination Services: The institute's library section received a total of 2,166 documents, including theses, journals, magazines, annual reports, books, and newspapers.

Mapping Activities: The Institute created location and footprint maps for all the CSIR institutes. Also, work on the Ghana Districts Database with information on settlements, rivers, road networks, district boundaries, and contours was continued. A total of 129 Metropolitan, Municipal and District Assemblies (MMDAs) databases across the Western, Western North, Ashanti, Central, North East, Greater Accra, and Ahafo regions were created. Also, the 2021 population census data was used to generate population density maps for all the sixteen (16) regions of Ghana.

Ghana Journal of Science (GJS) & Ghana Journal of Agricultural Science (GJAS): CSIR-INSTI publishes GJS and GJAS, Ghana's leading science journals. *Ghana Journal of Agricultural Science Vol. 58(1) (2023)* and *Vol. 58(2) (2023)* published twelve (12) and sixteen (16) articles each. *Ghana Journal of Science Vol. 64(1) (2023)* and *Vol. 64(2) (2023)* published seven (7) and nine (8) articles respectively.

Staff Strength: The staff strength of CSIR-INSTI stood at eighty (80) as at 31st December 2023, comprising thirty-two (32) senior members, thirty-three (33) senior staff, and fifteen (15) junior staff. Two (2) staff members retired during the year.

Finances: Total receipts for the year under review amounted to GH¢8,334,093.61 and payments totaled GH¢8,324,712.55 with a surplus net receipt of GH¢9,381.06. The receipts were made up of salaries paid by the Government of Ghana (GOG) from the Consolidated Fund amounting to GH¢7,133,530.70. The Internal Generated Fund (IGF) amounted to GH¢388,098.45 and Donor Funds of Gh¢812,464.46. The IGF activities included Printing, Hiring of facilities, and Consultancy.

Main Collaborating Institutions:

- Alliance for Bioversity International and CIAT (ABC)
- International Institute of Tropical Agriculture (IITA)
- Kwame Nkrumah University of Science and Technology (KNUST)

- CSIR-Water Research Institute
- CSIR-Animal Research Institute
- ESOKO
- CABI
- Google via Junior Achievers (JA) Ghana
- German Federal Ministry of Education and Research (BMBF)
- Presbyterian University College Akropong Campus
- University of Environment and Sustainable Development (UESD)
- Local Government
- Global Open Initiative Foundation
- Mirza Ghulam Qadir Shaheed I.T Research Lab & Centre
- University of Copenhagen
- University of Ghana
- State Of North Rhine-Westphalia-Germany

1.0 INTRODUCTION

The mandate of the CSIR-Institute for Scientific and Technological Information (CSIR-INSTI), is to develop a national capacity and capability for the efficient and effective provision of scientific and technological information on demand for the benefit of research scientists, policy decision-makers, industrialists, etc. in an appropriately packaged form for national development.

The Institute's operative objectives include to:

- Collect, process, store, and repackage for dissemination of science and technology information embodying the results of indigenous science and technology research activities as well as those generated elsewhere for the benefit of planners in government, production, and manufacturing concerns
- Carry out research into the Electronics/Communications and uptake of research findings to end-users
- Utilise and develop ICT tools and communication devices for socio-economic development
- Provide sustainable training programmes in the fields of ICT and consultancy services using appropriate technologies and expertise
- Adopt, adapt, and master known and existing technologies
- Conduct research into the following areas:
    - ◊ Intelligent Transport Systems (ITS)
    - ◊ SMART Agriculture for Sustainable Green Cities
    - ◊ High-Performance Data Networks and Cybersecurity
    - ◊ Computer-Aided Designs and Robotics
    - ◊ Predictive Analytics and Algorithm Development

- Undertake science publishing services and ultimately become a leader in the speciality in Ghana.
- Collect and analyse data for the design and construction of thematic maps using digital technologies to depict Ghana's resources and development potential to aid planning, policy decision-making, research, and general education
- Support the promotion of efficient research and development activities in the country through the provision of science and technology information services using appropriate information processing and communication technologies
- Strengthen national science and technology information and infrastructure through effective networking and collaborative activities

CSIR-INSTI continued to collect, organise, coordinate, manage, and repackage for dissemination, STI resources on a national scale to facilitate technology transfer between the developers or producers of technologies to enhance and accelerate the adaptation and diffusion of these technologies, in fulfilment of its mandate.

Technical divisions of the Institute under which activities were undertaken were:

- Communications Division
- Electronics Division
- Fluid Science Division
- Geospatial and Information Science Division
    - ◊ Geographic Information Systems Section
    - ◊ Scientific Information Management Section
- Printing and Publishing Division
    - ◊ Science Publishing Section
    - ◊ Printing Section

Supporting divisions:

- ◊ Accounts
- ◊ Administration

2.0 RESEARCH & DEVELOPMENT PROJECTS

The Council for Scientific and Industrial Research (CSIR) is mandated to generate and apply innovative technologies, and efficiently and effectively exploit Science and Technology (S&T) for socio-economic development in critical areas of agriculture, industry, environment, some aspects of public health, and social sciences. Additionally, CSIR's mandate includes improving the scientific culture of civil society in Ghana; with the ultimate goal of promoting accelerated national development. The Research and Development (R & D) programmes of the CSIR are grouped under seven thematic areas, namely:

- Food Security and Poverty Reduction
- Climate Change, Environmental Management and Green Technology
- Materials Science and Manufacturing
- Energy and Petroleum
- Bio-medical and Public Health
- Electronics and ICT
- Science and People

CSIR-INSTI during the year carried out research under 3 of these 7 thematic areas:

» Climate Change, Environmental Management and Green Technology

» Electronics and ICT

» Science and People

2.1 Climate Change, Environmental Conservation and Green Technology

2.1.1 Changes in Ecosystem Services in Riparian Forests Amidst Climate Change: A Case of The Densu River Basin

Research Team:	Allotey, A. N. M., Asiamah, T. A., Limantol, A. M., & Wiafe, E. D.
Start Date:	June 2022
Completion Date:	February 2023
Sponsors:	CSIR-INSTI
Collaborating Institutions:	University of Environment and Sustainable Development (UESD), Dodowa
Location:	University of Environment and Sustainable Development (UESD), Dodowa

Introduction

Riparian forested catchments consist of freshwater, vegetation and all life species that depend on the water and vegetation, including human life. These dynamic ecosystems provide a greater portion of water for domestic, agricultural, commercial, and ecological needs of the environments upstream and downstream the catchment. The hydrological and geomorphic setting can be affected by natural and anthropogenic activities interacting at multiple spatial and temporal scales to influence the composition, ecological processes, and ecosystem functions of the catchment. Consequently, the functions of forested catchments are highly susceptible to climate change and anthropogenic activities.

Each component of the catchment provides functions that sustain life in the ecosystem and also provide services for human life. The freshwater serves as a habitat for various aquatic species such as fishes, invertebrates, floating and submerged aquatic macrophytes, and other aquatic flora and fauna. The water also helps in regulating flooding and droughts in the catchment. The hydrological regime influences several

physical and chemical properties of freshwater systems, such as soil and water salinity, nutrient availability, soil anaerobiosis, pH, and deposition and removal of sediments. This makes the environment stable for the various fauna and flora species. Studies reveal that through feedback mechanisms, changes in the physical and chemical properties of freshwater systems and interactions with biotic components can influence and change the hydrological regime. The forest regulates water flows and influences the availability of water resources, and serves as a habitat for animal species found in the catchment. This has been a contributor to some processes such as carbon sequestration and storage. The forest also protects the freshwater system, serving as a water purification component and a source of bioenergy for human life and feed for animal species. Human life is directly and indirectly dependent on forest catchments through the provision of livelihood sources. Fishing activities are carried out in the freshwater, while food is obtained from the forest through farming activities. Furthermore, water from the freshwater system serves domestic purposes, watering livestock, crop irrigation and other commercial purposes. Fuel wood is also obtained from the forest. Cultural values are also obtained from both the water bodies and forest resources. In many cases, the natural resources surrounding communities drive the livelihood activities of the communities. Communities trade around the natural resources and their value chains to the extent that the prevention of access to the resources for any reason results in economic and social implications. A study on the Densu River Basin reveals social and economic costs such as unemployment, decreasing incomes, increasing crime rates, out-migration, etc., following conservation strategies which prevented communities from using the water resources. This study differs from previous studies by employing a multi-approach to examine the changes in land use/land cover over time. Biophysical, social and anthropological approaches are employed in this study.

Objectives

To assess the changes in ecosystem functions of the Densu River Catchment over a period of 30 years and establish the underlying causes of the changes.

Materials and Methods

1. Remote sensing technique is one of the modern tools used to monitor changes in the land use and land cover. On that basis, the research made use of satellite

imagery to analyse the land use/land cover changes over 30 years (1991, 2002, and 2021). The specific years were selected based on availability of satellite imagery and those with less than 20% cloud cover. The satellite scenes were acquired in the dry season to minimise the influence of seasonal variations and for effective comparison. Besides, ancillary data consisting of existence land/use cover maps and Global Position Systems (GPS) points recorded from the field complemented the analysis. The Landsat imageries were downloaded from the USGS website.

2. Socio-economic survey: The communities within the Densu River Basin (DRB) catchment constituted the study population. A total of 14 communities along the DRB were selected for the study. The DRB was segregated into three. The upstream towns included Mangoase, Akwadom and their environs. The mid-streams Nsawam, Doboro and their environs were selected. Finally, Weija, Oblogu and their environs were selected as downstream towns. A total of 458 respondents were interviewed in the survey by administering a questionnaire to all the respondents.

Major Findings

- The study finds that Land-use/land-cover changes in riparian areas are associated with changes in ecosystem services.
- Change in land use/land cover is associated with a decline in food provisioning functions of the forest and water resources over time.
- Changes in ecosystem services vary along the segments of the riparian zone.
- There is a need for sustainable agricultural practices to prevent the rapid conversion of forest land to agricultural lands.

Expected Beneficiaries/Potential Impact

- Promote environmental monitoring within the Densu basin.
- Help the various municipal, metropolitan and district assemblies to manage the basin activities.

Publications from Project

Asiamah, T. A. & **Allotey, A. N. M.** (2023) Land use competition and changes in ecosystem services in riparian areas for a period of 30 years (1991-2021/2022)- (Submitted for publication)

2.1.2 A Geospatial Inventory System for Sustainable Mobility in Ghana

Research Team:	Dziwornu, M. G., Kofie, R. Y., Allotey, A. N. M., Laryea, B. & Agyarko, F. F.
Start Date:	October 2022
Duration:	10 years
Sponsors:	CSIR-INSTI
Collaborating Institutions:	None
Location:	Accra, Ghana

Introduction

Sustainable transport and mobility are important ways to help achieve Sustainable Development Goals (SDG). More specifically, the Global Plan for the Decade of Action for Road Safety 2011–2020 released in 2011 included road traffic injury prevention as Target 3.6 of the Sustainable Development Goals (SDG) in 2015. Poor road network infrastructure is a growing problem around the world and in developing countries. The implications of poor road infrastructure on road traffic and pedestrian safety and economic development have been well documented. For instance, poor road surface conditions are one of the leading causes of road accidents in many parts of the world.

In many African countries, road accidents are the third major cause of fatalities after Malaria and HIV/AIDS. Statistically, it has been noted that 72 persons per 100,000

population sustained serious injuries, and about eight persons per same population died from Road Traffic Accidents (RTAs) over the past decade in Ghana. Demographically, more than 60% of road traffic fatalities were children and young persons under 35 years of age. A plethora of studies on risk factors associated with road traffic accidents in Ghana reveal most causes are driver-centric, such as over-speeding, reckless overtaking, drunk and fatigued driving. There is, however, little work on how to leverage information and communication technology systems such as geospatial technologies for road traffic and pedestrian safety improvement.

Objectives

This project proposes a mapping system to detect road anomalies such as potholes for pedestrian and driver safety.

Materials and Methods

The first part of the methodology was divided into two phases. These are the App/Web Development Phase and the Telegram Bot Creation Phase. Below is a detailed elaboration of the various phases in the methodology.

1. App/Web Development Phase: The website's main features include a geolocation API integration with Google Maps API that allows users to easily identify the location of the pothole and store an image of the pothole. The website is designed to be user-friendly and accessible to users of all levels of technical expertise. This phase was accomplished in two respective stages.

Stage One (Ui/Ux Design): The website was designed with user experience in mind to ensure that users can easily navigate and use the platform. The website design is user-friendly and responsive on all devices, including mobile phones and tablets, making it accessible to users regardless of their device. When a user opens the website, they are presented with the homepage, which includes a call-to-action button prompting them to get started. Upon clicking the button, the user is redirected to the registration page where they can enter their name and phone number to register on the platform.

After a successful registration, the user is redirected to the data collection page where they can click the "Get Location" button to capture the GPS location of the pothole. The user can then upload pictures of the pothole and submit them to the database. The user interface was designed with simplicity and ease of use in mind to ensure that users can quickly and easily complete the data collection process. The design also incorporates visual cues and clear instructions to guide users through the process and ensure that they understand what is expected of them. Overall, the UX design of the website is intuitive and user-friendly, making it easy for users to contribute to the database and help improve road safety in Ghana.

Stage Two (Technical Details): The website was built using HTML, CSS and JavaScript. The team used Visual Studio Code as the primary Integrated Development Environment (IDE) for development. One of the major technical challenges encountered during development was making the website responsive on all devices, including mobile phones and tablets. However, the team was able to overcome this challenge by implementing a mobile-first design approach and using responsive design techniques such as media queries and flexible grid layouts. The team also utilised various libraries and frameworks to enhance the website's functionality and performance. For example, they integrated the Google Maps API to allow for geolocation data collection, and they used jQuery to simplify and streamline the JavaScript code.

2. Telegram Bot Development Phase: To achieve this goal, the following steps were taken as detailed below.

Bot Registration: This began by registering our bot with the Telegram protocol and obtaining an access token. The access token allowed the bot to interact with Telegram users.

Enabling Location Feature: Next, we enabled the "location" feature for our bot by sending the '/setprivacy' command to the Telegram protocol and setting the privacy mode to "disabled". This allows our bot to receive location updates from users.

Extracting Pothole Location Data: When a user shares the pothole location with our bot, the bot receives a message containing the location coordinates in the format of latitude and longitude. We use the Telegram API to extract these coordinates and store them in a database.

Establishing Database Connection: To store the location data in a database, we needed to establish a connection to the database. We used Python programming language and PyMySQL library to connect to a MySQL database.

Creating Table for Location Data: Once the connection was established, the team created a table in the database to store the pothole location data. The table had columns for the latitude, longitude, and other relevant information such as the user ID, date and time of the location update.

Inserting Pothole Data into Database: When the bot receives a new location update from a user, it inserts a new row into the table with the location coordinates and metadata. The team utilised SQL queries to insert data into the database.

Retrieving Data from Database: To retrieve location data from the database, we used SQL queries to filter the data based on various criteria such as user ID, date and time, or location proximity. The bot could then use this data to provide location-based services to users such as displaying nearby points of interest or providing directions to a specific location.

Results Achieved So Far

To facilitate the automation and seamless transfer of GPS data from the Telegram app to our backend server, we have registered a Telegram bot through Telegram's BotFather. This bot collects GPS data from users and transmits it to the bot's database. To ensure the integrity and security of the system, we have implemented a user registration process. Users are required to provide their telephone numbers during registration. Upon registration, the bot generates a unique activation key and sends it to the provided telephone numbers. This activation key serves as a means of verifying and activating the user's access to the service. By implementing this process, we aim to prevent spam and maintain the reliability and credibility of the system. The project was developed using Java with Maven as the build automation tool. Maven is widely used for managing dependencies and building Java projects. To implement the REST service and the bot functionality, we utilised the Spring Boot framework. Spring Boot is an open-source Java-based framework known for its ability to create microservices and production-ready applications.

Way Forward

1. **Enhance Security Measures**
   - Implement end-to-end encryption for the transmission of GPS data to further secure user data.
   - Regularly update and patch the system to protect against potential security vulnerabilities.
2. **Improve User Experience**
   - Develop a user-friendly interface for the Telegram bot to enhance user interaction.
   - Implement a feedback mechanism to allow users to report issues or provide suggestions for improvement.
3. **Expand Functionality**
   - Consider integrating with other messaging platforms to broaden the user base.
   - Explore the possibility of collecting additional data types, such as weather or traffic conditions, to provide more comprehensive information to users.
4. **Performance Optimisation**
   - Regularly monitor and optimise the performance of the bot and the backend server to ensure smooth and efficient data transmission.
   - Implement load-balancing techniques to manage high volumes of data and prevent server overload.
5. **Continuous Testing**
   - Conduct regular testing to identify and fix bugs in a timely manner.
   - Implement automated testing to streamline the testing process and ensure the reliability of the system.
6. **Documentation and Knowledge Sharing**
   - Maintain comprehensive documentation of the system architecture, codebase, and operational procedures.

- Encourage knowledge sharing among the team to foster continuous learning and improvement.

7. **Compliance with Legal and Regulatory Requirements**
   - Ensure compliance with data protection regulations and respect user privacy.
   - Regularly review and update the system in response to changes in legal and regulatory requirements.

2.1.3 Climate Change Resilience in Urban Mobility

Research Team:	Kofie, R. Y. & Allotey, A. N. M.
Start Date:	June 2018
Completion Date:	December 2023
Sponsors:	Ministry of Foreign Affairs of Denmark
Collaborating Institutions:	University of Ghana (Department of Geography & Resource Development) and University of Copenhagen (Department of Geoscience), Denmark.
Location:	Accra, Ghana

Introduction

The project aims at identifying research-based strategies for increasing climate change resilience within urban mobility, accessibility and transport in Accra, Ghana. It is to establish a comprehensive understanding of the physical factors that determine resilience to climate change impact on mobility and accessibility in the Accra Metropolitan Assembly (AMA). This was accomplished by enhancing research capacity in the field, introducing new methods for mobility analysis, new methods for predicting urban floods, and by devising policy and planning measures to advance the sustainable urban development agenda. The research and capacity building were expected to lead to a reduction in inequality in access to mobility and, thereby, the reduced vulnerability

of local communities challenged by unsustainable spatial development practices and increased frequency of extreme weather events.

Objectives

- Identify strategies for increasing climate change resilience within urban mobility, accessibility, and transport in Accra, and
- Investigate how these strategies may be integrated into the urban planning and decision-making process.

The project aimed to:

- Enhance research capacity in the field, introduce new methods for mobility analysis, new methods for predicting urban floods, and
- Devise policy and planning measures to advance the sustainable urban development agenda.

Materials and Methods

This interdisciplinary research effort drew upon the combined competences of the involved North and South partner teams within climate change scenarios, flood modelling, urban planning, socio-economic analysis, and GIS-based spatial analysis. The project applied a combination of quantitative and qualitative methods to address the objectives of the different work packages. The quantitative methods included questionnaire surveys, computerised analysis of local and city-wide elevation models, satellite images as well as GIS-based analysis of the urban transport networks in terms of risk of flooding, connectivity and level of redundancy. A small UAV "drone" was applied to collect local elevation data for evaluation purposes. A city-wide elevation model based on satellite images was obtained for the project. The qualitative methods included focus groups, key informant interviews, field observations, in-depth qualitative interviews and participatory community workshops.

Major Findings

1. ***Work package A. Urban mobility patterns, livelihood strategies and vulnerability***

Local mobility patterns and practices embedded in the livelihood strategies of urban residents in the four selected urban settlements, and analysis of these practices within the context of climate change resilience were explored.

2. ***Work package B. Scenarios of climate change and urban flooding***

How climate change will affect future urban flooding patterns was analysed with a focus on the influence of climate change on the future precipitation pattern in the region. Using a newly developed method for forecasting how storm water will flow in urban areas during extreme rain events and mapped using a small UAV ("drone") equipped with a Lidar scanner.

3. ***Work package C. Transport network analysis: Impact of flooding on urban accessibility and mobility***

Spatially how flooding events directly affect the transport network by reducing network connectivity, accessibility and general speed levels, and how this further affects levels of mobility and accessibility in different urban areas.

Expected Beneficiaries/ Potential Impact

- Research Community
- Households, Municipal and District Assemblies, opinion leaders, researchers and policymakers.
- Emergency Institutions, Transportation Institutions and the Government of Ghana

Publications from Project

About 54 publications and reports available at https://ign.ku.dk/english/climaccess/. They include journal papers, conference presentations, conference publications, project technical reports, policy briefs and Master's thesis reports.

2.1.4 A Geo-Spatial Perspective of Floods, Transport Networks and Emergency Responders/Services in Accra

Research Team:	Kofie, R. Y., Allotey, A. N. M., Annor, J., Lettu, C., & Davidson, E.
Start Date:	June 2021
Completion Date:	June 2023
Duration:	2 years
Sponsors:	DANIDA/DFC/FFU
Collaborating Institutions:	University of Ghana & University of Copenhagen, Denmark.
Location:	Accra, Ghana

Introduction

Much research has been done on floods in urban Accra. Some of the studies have pointed to the hydrological dimensions and risk management and interrogations into the causes, effects or impacts, and the coping strategies adopted by the communities affected by the floods. They also include recommendations on the possible sustainable developmental policy options necessary to address the flood menace. What has been overlooked is the emergency interventions that are required during flood events. If they become casualties, people trapped in floods in homes or outside homes need to be evacuated to safe locations or hospitals. Several factors come into focus, and prominent among these is the interplay between floods, the transportation or road networks and access to emergency response services.

Objectives

The main aim was to assess the interventions that are required during flood events, with the following objectives:

- Identify the various emergency services
- Map out the emergency services using GPS

- Introduce new methods for mobility analysis,
- Identify new techniques for predicting urban floods, and
- Devise policy and planning measures to advance the sustainable urban development agenda.

Materials and Methods

This study intended to draw on existing datasets gathered within the CLIMACCESS project, such as flood-prone locations and city-wide transport network. This was complemented by field data on the location of emergency services such as:

- Hospitals/Polyclinics
- Police Stations and Posts
- Fire Service
- National Disaster Management Organisation (NADMO)
- Ambulance Services
- Ghana Red Cross Society

Further, data was compiled on the population to determine access to these service centres in the delineated localities or catchment areas.
Overall, it was intended for the study to ascertain the location of flood areas. These populations live within the localities or communities that fall within the flood areas, access roads and distances within which emergency services could be provided. Network analysis was the geospatial tool applied.

Major Findings

- The results demonstrated the fastest routes to flood hotspots by emergency services.
- Flood hotspots mapped in all the study sites thus, Adentan, Glefe, Pokuase and Santa Maria.
- About 20% of the fastest routes generated have impedances or obstacles.

- In many cases, most of the flood hotspots are accessible through the inner roads within the community.
- Emergency responses can equally rely on Google Maps to their various hotspots.

Expected Beneficiaries

- Emergency Service providers (Ghana Fire Service, Ghana Ambulance Service, NADMO)
- Planning officers within the various Assemblies
- Ghana Red Cross Society

Publications from Project

Manuscript has been submitted for publication.

2.2 Electronics and ICT

2.2.1 Mapping of Climate-Smart Agriculture Practices in Ghana

Research Team:	Dziwornu, G. M., Agyarko F. F., Odonkor E. N., Wilson, M., Sackey, T. A. & Abdulai, S. M.
Start Date:	September 2023
Completion Date:	December 2023
Sponsors:	The Alliance of Bioversity International and CIAT
Collaborating Institutions:	The Alliance of Bioversity International and CIAT
Location:	Ghana

Introduction

Agriculture remains crucial to Ghana's economy, livelihoods and food security, contributing 20.3% of GDP in 2015 (Ministry of Food and Agriculture, 2021). However, climate change creates mounting pressures on agricultural productivity and sustainability nationwide. Ghana has experienced rising temperatures, increased variability in rainfall, and more extreme weather events over the past decades. Climate shocks undermine crop and livestock yields, raise production risks and costs, lower incomes, and exacerbate hunger and poverty levels for smallholder farmers (Kuma et al., 2019). Responding to these escalating climate change challenges necessitate systematic adaptation and mitigation strategies mainstreamed across Ghana's agricultural sector.

Climate-smart agriculture (CSA) has emerged since 2010 as an integrative approach centred on the sustainable intensification of agriculture to address food security and climate change concerns simultaneously (FAO, 2017). The FAO defines CSA as "an approach aimed at transforming and reorienting agricultural development under the new realities of climate change" (Lipper et al., 2014). Specifically, CSA seeks to achieve three interlinked objectives: sustainably increasing productivity and incomes, strengthening adaptive capacity and resilience, and reducing/removing greenhouse

gas emissions where possible (FAO, 2013). The realisation of CSA outcomes relies on the widespread adoption of suitable technologies, practices and services tailored to local contexts. CSA necessitates coordinated policy and programmatic efforts engaging diverse actors across regions and farming systems.

Policy Framework for CSA in Ghana

To address the threat posed by climate change to food security and livelihoods, Ghana developed a National Climate Change Strategy in 2008, which outlined 10 cross-sectoral programmes. However, these programmes were not well integrated into sectoral policies and plans, resulting in ineffective implementation. To improve the coordination and effectiveness of climate change actions, Ghana established a National Climate Change Committee (NCCC) in 2010, led by the Ministry of Environment, Science and Technology. The NCCC developed the National Climate Change Policy (NCCP), which was launched by the President of Ghana in 2014. The NCCP identifies seven pillars for implementing the climate change policy, such as governance, capacity building, finance, international cooperation, communication, and monitoring. The NCCP also prioritises five main areas of intervention: agriculture and food security, disaster preparedness and response, natural resource management, equitable social development, and energy, industrial and infrastructural development. The NCCP aims to ensure a climate-resilient and climate-compatible economy while achieving sustainable development through equitable low carbon economic growth for Ghana.

To provide impetus to CSA, the government of Ghana approved a Climate-Smart Agriculture and Food Security Action Plan (CSAIP) in 2016. Grounded in the objectives of the National Climate Change Policy (NCCP), the CSAIP strategically applies 'climate-smart' practices to strengthen productivity, climate resilience, mitigation, and food security. The CSAIP is informed by key policies and strategies such as the Food and Agriculture Sector Development Policy (FASDEP), the Medium Term Agriculture Sector Investment Plan (METASIP) and the Agriculture Sustainable Land Management Strategy and Action Plan. The CSAIP highlights the importance of generating evidence of the most effective and efficient CSA technologies, increasing agricultural productivity and income, enhancing resilience of the agricultural system and reducing greenhouse gas emissions.

Status of CSA Implementation

Annual budget analysis from 2020-2023 shows the government has committed significant financial resources to supporting various CSA activities, including agricultural input subsidies, irrigation infrastructure expansion, afforestation programmes, and support for legumes and tree crops. For instance, budgets showed fertiliser distribution increased from 342,200mt in 2019 to over 350,000mt annually in 2020-2022, benefiting over 1.5 million farmers each year. Also, significant investments were made in construction/rehabilitation of dams and boreholes. For example, 6,766ha of land was made irrigable through schemes completed in 2023. Furthermore, millions of tree seedlings were planted annually under national programmes. For example, 75,170ha was afforested in 2020, with 3.7 million seedlings distributed. Additionally, distribution of improved legume seeds like soybean and cowpea expanded from 18,333mt in 2019 to over 29,500mt targeted in 2020-2021. Similarly, over 23 million certified seedlings of cashew, coffee, coconut and oil palm were distributed from 2019-2022 to hundreds of thousands of farmers. Massive investments supported rehabilitation, irrigation expansion, and subsidised fertiliser and seedling distribution benefiting over 1 million cocoa farmers. New hatcheries, ponds and cages were constructed under programmes like Aquaculture for Food and Jobs, while the National Aquaculture Centre was established.

Objectives

Mapping CSA efforts in Ghana would provide an invaluable tool to guide strategic planning and expansion. To support efforts towards CSA adoption practices, the project conducted a comprehensive survey of government agencies, NGOs, and private sector actors involved in CSA promotion, training, and implementation in Ghana. Furthermore, the project aimed to interview key informants in each organisation to identify personnel working with CSA databases and spatial datasets as well as compile organisational mandates, areas of influence, CSA focus areas, and spatial data resources into a comprehensive directory. The project also utilised organisational mapping to develop a suitability model to map potential areas for further CSA expansion based on biophysical, infrastructure, market access, and adoption likelihood covariates, and provide suitability maps to guide cost-effective selection of new CSA project sites.

Materials and Methods

The analysis utilised a mixed methods approach combining qualitative, spatial, statistical, and social network analyses to assess CSA landscapes in Ghana. It mapped government, NGOs and private sector actors engaged in CSA promotion, training and implementation across regions. It reviewed project documents to analyse CSA systems, thematic areas, technologies, social outcomes, and feasibility. Spatial visualisation conveys the geographic distribution and concentration of CSA activities. Statistical analysis identified significant influences on social outcomes. Social network analysis examines relationships between organisations, technologies, and regions.

Major Findings

Climate Smart Agriculture (CSA) is critical for food security in Ghana given projected climate change impacts. This project involved mapping organisations involved in CSA promotion in Ghana and developing spatial datasets on current practices. A comprehensive desk review identified 167 past CSA initiatives from which organisational mandates were compiled into a stakeholder directory. Initial screening prioritised practices for suitability modelling. The methodology combines organisational mapping, spatial analysis, and suitability modelling to guide CSA expansion planning. Surveys were administered to leading CSA implementing agencies across government, research institutions and NGOs to document their geographic coverage, technologies used, and outcomes achieved. The collated organisational insights reveal capabilities, influence areas, and coordination needs. The spatial datasets and stakeholder directory would inform the development of a suitability model to identify priority areas for scaling CSA. The outputs include an institutional CSA database, adoption hotspot maps, suitability model, and an interactive information portal to enable inclusive and systematic planning for climate-smart agriculture expansion in Ghana.

Expected Beneficiaries/Potential Impact

The Government of Ghana (Ministries, departments, and agencies); International development agencies; Non-governmental organisations; Universities and research institutions. Ghana has established strong policy frameworks and invested financial resources to promote climate-smart agriculture nationwide. While successes have been

achieved, uptake of CSA practices on the ground remains limited, especially among vulnerable smallholder farmers. The analysis finds that CSA implementation exhibits geographical imbalances.

To substantially enhance the resilience of Ghana's agricultural sector and food security, scaled implementation of inclusive, gender-sensitive CSA is imperative across the country. Achieving this requires concerted action along the following dimensions:

- Strengthen coordination between extension services, universities, NGOs and the private sector through mechanisms such as public-private partnerships.
- Develop clear incentive structures to encourage private sector investment in CSA supply chains, technologies and climate-resilient infrastructure.
- Design and disseminate user-friendly CSA manuals tailored to different agro-ecological zones using farmer field schools and women's groups.
- Promote integrated livestock/fisheries/crops systems better adapted to local conditions across regions.
- Increase accessibility to proven soil/water management and agroforestry techniques through demonstrations on public/private farms.

Publications from Project

Policy Briefs

Mponela, P., **Dziwornu, M. G.**, **Agyarko-Fosu, F**., Inusah, S., **Odonkor, E. N., Sackey, T. A., Mamah, S. A.** & Akpatsu, I. B. (2023) Climate-smart agriculture implementation evidence in Ghana: Supporting scaling strategies for enhanced resilience in Ghana. AICCRA Ghana Cluster Reports 2023. 8 p.

Mponela, P., **Dziwornu, M. G.,** Inusah, S., **Agyarko-Fosu, F., Odonkor, E. N., Sackey, T. A., Mamah, S. A. &** Akpatsu, I. B. (2023) Towards optimised climate-smart agriculture resource investment decisions: Mapping programme impact areas, policy support and mitigation feasibility. AICCRA Ghana Cluster Reports 2023. 93 p.

2.2.2 Enabling Deep Learning Inference on Low-cost Edge Devices: A Case Study of Crop Pest and Disease Identification

Research Team:	Gookyi, D. N. A., Wilson, M., Ahiadormey, K. R. & Danquah, P.
Start Date:	January 2023
Duration:	24 months
Sponsors:	UNESCO-TWAS program (Seed Grant for African Principal Investigators) financed by the German Federal Ministry of Education and Research (BMBF).
Collaborating Institution:	Department of Telecommunication Engineering, KNUST
Location:	CSIR-INSTI & KNUST

Introduction

Crop pests and diseases are a major hindrance in the agriculture field globally. The Food and Agriculture Organisation (FAO) report indicated that crop pests and diseases cause about a 40% loss in global crop production. To curb crop pests and diseases, farmers use a variety of pesticides and chemicals to increase production. The continuous and excessive use of pesticides and chemicals on crops results in several human illnesses such as cancer and extreme respiratory issues. For this reason, advanced technological innovations are needed for the early detection of crop pests and diseases to prevent the undesirable use of pesticides and chemicals.

Several developed countries are advancing their agriculture sector by applying the fourth industrial revolution tools, which are mainly fuelled by Artificial Intelligence (AI), robotics, and the Internet-of-Things (IoT). The technologies are used in many aspects of agriculture including irrigation, fertilisation, crop health monitoring, and crop pest and disease control. A challenging area is the classification of crop pests and diseases because of the extremely complex structure and the similarity of most crop pests and diseases. Also, the traditional manual method of identifying crop pests and diseases is

time-consuming, expensive, and inefficient. Several AI techniques have been employed in the area of crop pest and disease identification to help in their early detection and alleviation.

Deep learning techniques, including Convolutional Neural Networks (CNN), have recently been used to identify crop pests and diseases in many works. When compared to the traditional machine learning algorithms, CNNs operate on direct raw pixels and consist of feature generators.

This project aims to investigate the practical implementation of deep learning algorithms on low-cost embedded devices to be used in identifying crop pests and diseases in Ghana. Many types of research focus on implementing deep learning algorithms on high-end computing devices such as Central Processing Units (CPUs), Graphics Processing Units (GPUs), and servers. This is usually the case because most deep learning algorithms are computationally intensive consuming a lot of resources such as bandwidth, memory, and power.

In the sector of agriculture, high-end computing devices cannot be deployed on farms for crop pests and disease identification. For this reason, this project will focus on implementing deep learning algorithms on reconfigurable platforms such as Field Programmable Gate Arrays (FPGAs). The FPGA platform is promising because it is reconfigurable, consumes low power, and is low cost.

The FPGA will be enabled to perform deep learning inference on the board in real-time without requiring external servers. This is done to enable farmers to quickly identify crop pests and diseases without the burden of internet connectivity which is extremely rare and high priced in most farming locations in developing countries. For commercial farms, the devices will be equipped with communication modules such as WiFi and Bluetooth to transfer information to high-end devices for better visualisation and interpretation when mounted on Unmanned Aerial Vehicles (UAVs). The main challenge of implementing deep learning algorithms on the FPGA platform is that it requires a lot of expertise in the area of hardware development. This project will therefore recruit and train two graduate students in the area of hardware-software co-development to increase the number of hardware engineers in Ghana.

Objectives

1. Publish a dataset of crop pests and diseases in Ghana.

    b. Collaborate with researchers in the Council for Scientific and Industrial Research (CSIR) to identify the key crop pests and diseases that could be identified using deep learning algorithms.

    c. Deploy officers to manually collect images of crop pests and diseases in their natural habitat from across the country.

    d. Preprocess, organise the images into their various categories, and divide into a training set and a test set.

    e. Make the dataset available to the public by publishing them on a website.

2. Develop a framework for generating ideal deep learning models based on hardware-specific parameters.

    a. The dataset will be trained on several deep learning frameworks on a high-end computing device.

    b. Results from the various deep learning frameworks will be compared in terms of their overall accuracy, training time, and resource consumption.

    c. A framework for automatically generating an ideal deep learning model based on hardware-specific parameters will be developed.

    d. An ideal deep learning framework will be selected for deployment (inference).

3. Deploy the deep learning network on a low-cost FPGA platform.

    a. Design a custom hardware architecture for the deep learning framework using Register Transfer Level (RTL) hardware description languages.

    b. Synthesise the hardware architecture on available hardware design tools.

    c. Implement the hardware architecture on a low-cost FPGA development board.

Materials and Methods

The research methodology will encompass four main phases. The four phases detailed below will provide a step-by-step methodological framework to guide the recruited researchers for the entire project duration.

Phase 1: Definition of metrics, scenarios, functional requirements, and modelling and implementation toolkits.

This phase involves the development of a common understanding between the various participating institutions and recruited researchers. The institutions will include CSIR-INSTI, CSIR-CRI, and a selected university in Ghana. The recruited researchers will include farmers, extension officers, research scientists from the various participating institutions, and two postgraduate research students. The researchers will participate in deciding the architectural components, feasible designs, functional requirements, reference scenarios, designs, devices, and matrices for the design, development, optimisation, and implementation of the project technologies and solutions. This stage will consist of the following activities or functions by the researchers from the various institutions.

1. The researchers will provide a comprehensive review of current state-of-the-art designs, concepts, devices, metrics, and scenarios associated with the research objectives. This stage involves evaluating various existing solutions, publications, and patents by the researchers to help develop specific components of the research objectives

2. Based on the first step, the researchers will identify the suitable and specific matrices, scenarios, designs, and concepts that will meet the research objectives. This stage involves the development of standard metrics, models, concepts, and mechanisms that will be followed by all researchers within the project. Each scenario, concept, and design will be well-defined with a specific framework developed by the researchers under the principal investigators' supervision.

This phase will also help create a baseline for the design, development, and implementation of the various components of the research (including modelling,

optimisation techniques, component designs, and experimental setups). These baselines will help in the assessment of the various goals and stages of the research project. The researchers will also identify the appropriate software (including simulation, evaluation, and hardware synthesis software), cloud computing services, electrical components, and devices needed for designs, algorithms, and component development. These may include open-source or commercial products such as Vivado, Xilinx ISE, ModelSim, Efabless, ChipIgnite, Rocketchip System-on-Chip (SoC) generator, MATLAB, Pspice, FPGA boards, Arduino boards, National Instrument devices, and any available equipment or software already within the consortium. The researchers will also be required to review the theoretical backgrounds needed for the research project. These may include but are not limited to Deep Learning Concepts, Artificial Neural Networks, Deep Neural Networks, Convolutional Neural Networks, Recurrent Neural Networks (RNN), Tensorflow, Keras, Computer Architecture: RISC-V Version, Digital Systems Design, SoC Design, and Hardware-Software Co-design which may be needed within the research project.

Phase 2: Development of solutions and performance evaluation

Exploiting the findings, knowledge, and feedback acquired from Phase 1, the postgraduate research students will develop novel solutions and technologies for their graduate studies projects. The research objectives of the project will shape the individual research projects. However, the project challenges will be divided into personal graduate research projects due to the required research efforts. These projects will form the final graduation thesis for the postgraduate research students during their graduate studies. The individual projects are geared towards the development of the final deliverables of the project. These include research on image processing techniques, research on deep learning algorithms and their implementations, and research on efficient hardware architectures for deep learning algorithms. By exploiting the performance tools developed in Phase 1, the postgraduate research students will conduct extensive evaluation studies to assess the proposed technologies and solutions' performance.

Phase 3: Project integration and performance evaluation

Based on the various postgraduate students' outputs from Phase 2, the various institutions within the project will work together within this phase. In Phase 3, the

hardware and software integrations will be implemented. This phase of the project will include collaborating with researchers in CSIR-CRI to identify the common crop pest and diseases affecting farmers, manually collect crop pest and diseases images from their natural habitat, validate, create, and publish a Ghana crop pest and disease dataset to be used by interested parties, identifying and training the crop pest and disease on an ideal deep learning algorithm, designing custom state of the art inference hardware architecture for the deep learning algorithm, deploying and testing the deep learning inference hardware architecture on an FPGA development board. The deep learning inference on the FPGA board would then be tested within the laboratory setting (a controlled environment). Within this setting, system integration issues will be fixed, and the system will be tested and evaluated for the next phase, which involves field testing.

Phase 4: Optimisation and proof-of-concept study

This phase of the project will involve farmers, extension officers, postgraduate research students, and the principal investigator to perform field experimentation on the crop pest and disease identification device. The field experimentation will involve a small-scale farm, a large-scale farm, and a greenhouse. On the small-scale farm, the device will be handheld and used to examine crop pests and diseases on the farm. The type of crop pest or disease will be displayed on the device for the farmer to know if his farm is in danger of infections. The handheld device will not require internet access because all processing will be done on the device. On the large-scale farm, the device would be mounted on a drone and used to examine crop pests and diseases on various sections of the farm. The device will identify various crop pests and diseases on sections of the farm. The location and type of crop pest or disease will be sent to a web application for real-time monitoring. In the greenhouse, the device will be mounted on the roof of the greenhouse with a movable camera to monitor crops. An identified crop pest or disease will immediately be sent to a web application for observation by the farmer. With the in-field testing, final system optimisation and fixes will be implemented. This would help present the final deliverables of the project (Fully functioning deep learning inference on an FPGA board for crop pests and diseases identification).

Results Achieved So Far

Two MSc students from the Department of Telecommunication Engineering at KNUST were recruited for the project. They include Mr. Fortunatus Aabangbio Wulnye and Ms. Ewura Essanoah Arthur.

Pieces of equipment purchased for the work include:

1. EDGE Artix 7 FPGA Development Board (Quantity: 4)
2. Arduino Tiny Machine Learning Kit (Quantity: 4)
3. Adalm Pluto SDR Device (Quantity: 2)
4. Xilinx ZYNQ Ultrascale+ ZCU104 FPGA Board
5. HP AIO 24-DP1038NY 24 INCH TOUCH I5-1165G7 11TH GEN 8GB 1TB DESKTOP WINDOWS 10 (Quantity: 3)
6. HP DeskJet 2710 All-In-One Printer with Wireless Printing
7. MTN TurboNet Super High-speed 4G Internet Router

Dataset curation: The dataset encompasses distinct categories, including Blight, Common Rust, Gray Leaf Spot, Streak Virus, and Healthy leaves. These high-quality images were meticulously sourced from reputable repositories, including Kaggle, Harvard Dataverse, and Mendeley Data, ensuring their authenticity and relevance to agricultural research. The original images within the dataset exhibit varying dimensions and are provided in JPEG format. To streamline analysis and ensure consistency, augmented images have been included, each resized to a uniform dimension of 96×96 pixels. This transformation maintains the integrity of the data and simplifies the research process. In total, the dataset used for this study comprises a combined set of raw images, totalling 12344 instances, and augmented images, amounting to 7454 colour images. This extensive dataset presents a wealth of resources for researchers, agricultural experts, and machine learning practitioners, fostering advancements in disease detection and classification in maize crops. The number of images per class include Blight (4099), Common Rust (3480), Gray leaf Spot (4159), Healthy (3948), and Streak Virus (4109).

Machine learning platform selection: Edge Impulse and TensorFlow are both powerful machine learning platforms that can be used for maize crop disease detection. However, they have different strengths and weaknesses that should be considered before choosing one over the other. Our results show that Edge Impulse outperforms TensorFlow on most metrics, especially on inference time and power consumption, which are critical for edge applications. More specifically, the TensorFlow offers more control and customisation over the ML pipeline and model architecture. In conclusion, by combining these two platforms, we exploited the power of TensorFlow for training complex neural networks and the simplicity of Edge Impulse for deploying them on resource-constrained edge devices to push the boundaries of maize leaf disease identification and classification.

Model selection: The latest technology for image classification jobs is CNNs, which are made to automatically detect and identify patterns in input images and use those patterns to create feature maps that are then processed by a deeper layer. Some examples of CNNs include ShuffleNet and SqueezeNet. These are efficient CNN architectures tailored for resource-constrained devices. ShuffleNet employs channel shuffling and pointwise group convolutions for high performance with lower computational costs. SqueezeNet utilises fire modules to achieve a compact network design without compromising accuracy, ideal for edge devices with limited resources. These CNNs were not selected due to their high model sizes for the selected microcontroller unit (MCU) for this work. Modifying these models can increase device performance but may reduce accuracy for classification purposes. The CNN employed in this work comprises 3 convolutional layers with a kernel size of 3 for each, 3 max-pooling layers, a flatten layer, a dense layer of 128 neurons, and a dropout rate of 0.25. The input layer comprises 27,648 features, with an output layer comprising 5 classes.

Model training: The Edge Impulse platform provides tools for data preprocessing, such as noise reduction and feature extraction/generation, making it easier to work with raw sensor data. The training process of the CNN involves setting hyperparameters such as the number of epochs, learning rate, and batch size, contributing to optimising the model's performance. The Adam optimiser, a variant of stochastic gradient descent, is utilised to minimise the categorical cross-entropy loss. During training, a "BatchLoggerCallback" is employed to monitor progress, providing insights into accuracy and loss metrics across epochs. The training dataset is batched and potentially

shuffled to enhance learning and prevent the model from getting stuck in local minima. The model undergoes iterative training for 20 epochs where forward and backward propagation optimises the network's parameters, aligning predictions closer to the actual labels. The model exhibits high accuracy, with training and validation accuracies at 96% and 95%, respectively, showcasing consistency between training and unseen data. While the training and validation loss are at 0.122 and 0.146 respectively.

Model testing: Edge Impulse platform facilitated our testing phase, unveiling the model's performance metrics: a test loss of 0.1479 and an accuracy of 94.56%. This phase used new data to assess the trained ML model's predictive ability. Test loss signifies the model's deviation from expected results, while accuracy indicates the proportion of correct predictions. These metrics serve as benchmarks for the model's effectiveness and generalisation on unseen data, showcasing a promising level of accuracy in this evaluation conducted through Edge Impulse.

Model deployment: Leveraging the capabilities of Arduino Nano 33 BLE Sense, our study focuses on deploying ML models in resource-constrained environments. Arduino BLE Sense is a compact board integrating sensors and Bluetooth low energy for IoT and edge computing projects. The model was tested using the Edge Impulse platform, and the performance of the model was evaluated based on accuracy and F1 Score. Blights scored an accuracy of 98.5%, Common Rust (97.3%), Gray Leaf Spot (89.7%), Healthy (98.1%), and Streak Virus (92.5%). The F1 Score considers both precision and recall, balancing the two metrics. Precision measures the accuracy of positive predictions made by the model, while recall measures the model's ability to identify all positive instances in the dataset correctly. The F1 score is the harmonic mean of precision and recall and ranges between 0 and 1, where higher values indicate better model performance. The F1 Scores are as follows: Blight (0.99), Common rust (0.98), Gray Leaf Spot (0.92), Healthy (0.99), and Streak Virus (0.93). these figures show that the model performs better in categorising the classes of maize leaf diseases studied.

Way Forward

Two journal papers are currently being prepared.

2.2.3 Hosting and Technical Support of the Ghana Agricultural Data Hub (AG-Data Hub)

Research Team:	Wilson, M., Gookyi, D. N. A., Danquah, P., Twum-Barimah, Y., Awotwi, J. P. & Ohene-Affih, B.
Start Date:	January 2023
Duration:	5 years
Sponsors:	Self-financed
Collaborating Institution:	IITA/ CGAIR / AICCRA
Location:	CSIR-INSTI

Introduction

Many agricultural projects in the recent past have identified digitisation as a key component in transforming agriculture to achieve the goal of feeding an increasing population, at less footprint, on less land, and with less water, in a changing climate with increasing demand for quantity and quality of food and non-food products from plants and animals. A key product in the heart of the digitisation agenda is the generation of massive data. Accelerating the impact of collected data in agriculture requires an infrastructure that facilitates seamless access amongst relevant stakeholders in formats that can be easily mainstreamed for different purposes including but not limited to policy-making, product development, data-driven decision support, etc.

Creating seamless access to data and information along the agricultural value chain promises a radical change in transforming agriculture and food systems around the world, towards eliminating hunger and poverty, creating truly sustainable climate-smart systems and meeting the 2030 Sustainable Development Goals. It is in the light of this that the Ghana Agricultural Data Hub (Ag-Data Hub) is being developed as a secure mission-critical, reliable, multi-tier and multipurpose digital data exchange backbone for information and data sharing among stakeholders and for the development of fact-based decision support systems to drive policy-making and to trigger a move towards sustainable climate-smart agricultural practices.

Objectives

1. To implement a support infrastructure for traditional data migration into Findable, Accessible, Interoperable and Reusable (FAIR) data formats.
2. To engineer a seamless data flow architecture and analytical tools for fast retrieval, analysis and providing complex insight into big data.
3. To implement APIs for data gaps bridging, information sharing among stakeholders and to serve the software developer community under defined contracts and MOUs.
4. To facilitate the development of Application layer decision support systems and dashboards based on information needs of various stakeholders in the value chain

Materials and Methods

Development would be carried out using PHP and VUE programming languages. The platform would be hosted on a local server as well as a virtual private server with stakeholders. Data collection, data warehousing and data mining would be performed on data generated by stakeholders.

Results Achieved So Far

A technical report on lessons learned from the implementation of the Ghana Ag-Data Hub was put together and is yet to be published.

Way Forward

Publication of technical report

2.2.4 Development and Deployment of Agricultural Advisory Platform

Research Team:	Wilson, M., Danquah, P., Gookyi, D. N. A., Ahiadormey, K. R. & Dziwornu, M. G.
Start Date:	February 2023
Duration:	1 year
Sponsors:	IITA
Collaborating Institution:	CIAT
Location:	CSIR-INSTI

Introduction

Smallholdings represent over 80% of the world's farms, mostly located in the Global South, and supply 50% of global food. The agriculture sector in Ghana employs about 47% of the country's labour force, most of which are smallholder farmers who produce about 80% of the country's total food. These farmers rely primarily on rainfed agriculture and are highly vulnerable to the impacts of climate change. In semi-arid northern Ghana, 90% of the population depends on rainfed agriculture for their livelihoods. These farmers seasonally make critical agronomic decisions regarding crop choice, planting dates and pest, disease, weed, soil fertility and water management, often based on suboptimal practices and information.

Enhanced agronomy management has a great potential to increase productivity, sustainability, efficiency and competitiveness of these smallholdings, which is characterised by low and variable yields and profitability, smallholder farming challenges include water scarcity, climate change, low resource use efficiencies and declining soil health. The Excellence in Agronomy programme aims to deliver an increase in productivity and quality per unit of input (agronomic gain) for millions of smallholder farming households in prioritised farming systems by 2030, with an emphasis on women and young farmers, showing a measurable impact on food and nutrition security, income, resource use, soil health, climate resilience and climate change mitigation.

Objectives

1. To develop a digital platform that will serve as a one-stop shop for extension officers, farmers, researchers and policy makers to easily access relevant data and information that is readily applicable to their respective needs.

2. To host tailor-made as well as dynamic advisory tools that have been developed from validated research outputs from the Excellence in Agronomy programme.

Materials and Methods

PHP and VUE programming languages are the development tools to be used. The platform would be hosted on a local server and a virtual private server with stakeholders. Data collection, data warehousing and data mining would be performed on data generated by stakeholders.

Results Achieved So Far

The project involved the development and technical implementation of the Agricultural Advisory platform, based on content gathering from experts in the field. The application's development involved careful consideration of requirements and features. Key aspects included defining user needs, specifying functional and non-functional requirements, designing an intuitive user interface and implementing robust functionality. The process aimed to create a user-friendly and efficient application that met both technical and user experience criteria. The team developed agro-advisory tools, including a digital cropping calendar on the Excellence in Agronomy Advisory Hub. This calendar guides farmers and extension officers year-round, considering region-specific parameters and crop types. The process involves accurately determining rain onset, validated content gathering, and generating customised calendars.

The mobile-compatible web app provides tailored guidance, optimising resource use, increasing productivity, and aiding decision-making. Users access contacts for input, insurance, and extension services, with prompts on risks and mitigation steps at each cropping stage. The system empowers farmers, promotes sustainable agriculture, and enhances livelihoods, aligning with the Excellence in Agronomy programme's goals. The advisory tool is accessible at https://eiahub.org/main/Croppingcalendar.

Way Forward

An Android Mobile App will be developed in the first quarter of 2024 and field trials would commence in the second quarter of same year.

2.2.5 Software Defined Radio Implementation of Power Saving Design for Full-duplex Wireless Self-Backhauling

Research Team:	Danquah, P. A, & Ahiadormey, R. K.
Start Date:	June 2023
Duration:	24 months
Sponsors:	CSIR-INSTI
Collaborating Institution:	None
Location:	CSIR-INSTI

Introduction

In wireless networks, the backhaul connects the core network to the base stations. As wireless networks become more dense, traditional backhaul connections such as fibre optic become inadequate due to cost, inflexibility and scalability issues. One solution to this challenge is using the same wireless spectrum for access and backhaul connections. This technique is referred to as wireless self-backhauling. Wireless self-backhauling is very attractive for efficient spectrum usage in future ubiquitous networks. A power-saving design was recently proposed for full-duplex wireless self-backhauling. The proposed design results also show that higher capacity can be achieved than conventional techniques.

Software-defined radio (SDR) is a reconfigurable radio communication system where most of the physical layer functionality is written in software. SDRs can be used to transmit and receive wireless signals, develop wireless communication standards and rapid prototyping novel wireless protocols. In this project, an experimental SDR testbed is developed to implement a power-saving design for wireless self-backhauling.

Objectives

To make wireless self-backhauling an attractive technology for future ubiquitous networks, novel designs are required to improve power efficiency and reduce the interference between access and backhaul links. The novel designs must be tested in real-world scenarios for validation and evaluation. The objectives of this project are:

1. Implement the power-saving design for wireless backhauling on the SDR hardware platform.

2. Evaluate the performance of the proposed design in terms of key metrics (e.g., power efficiency and capacity)

Materials and Methods

The programme is designed to achieve the outlined objectives of the project as enumerated in the following phases:

1. Phase 1 will review existing SDR solutions related to the project. This phase will also identify the software tools, evaluation metrics and implementation toolkits that are needed for the successful execution of the project.

2. Relying on the results of phase 1, phase 2 will involve building the software solution to implement the wireless self-backhauling design. The novel solution will be evaluated using test radio signals, and a troubleshooting stage will be required to correct errors.

3. In phase 3, a testbed based on SDR hardware will be implemented in a real-world wireless propagation environment. The SDR and associated software will be deployed for design validation and performance evaluation. The overall operation of the testbed will enable various insights into power-saving and capacity gains.

Results Achieved So Far

Successfully purchased two communication devices.

Way Forward

The expected outcomes of the proposed project are:

1. Software-defined radio testbed for wireless self-backhauling
2. Publication of SDR implementation in a peer-reviewed journal

2.2.6 Effectiveness of Online Career Development – A Case Study of the Grow with Google Ghana project

Research Team:	Wilson, M. & Danquah, P., Gookyi, D. N. A. Ahiadormey, R. K., Dziwornu, M. G., Twum-Barimah, Y., Awotwi, J. P. & Sackey, T. A.
Start Date:	July 2023
Duration:	12 months
Sponsors:	Junior Achievers (JA) Ghana/Google
Collaborating Institution:	JA Ghana
Location:	CSIR-INSTI

Introduction

The Information Technology industry is one of the fastest growing industries globally and in Ghana. Over the last few years, the industry has provided jobs and opportunities that have proven key to professional success. The IT industry offers quick employment opportunities in every sector, multiple career paths, and sometimes relatively easier career entry points than most professions.

JA Ghana, in partnership with Google, is offering scholarships to the youth to earn Google Professional Certificates on Coursera. These certificates provide great opportunity for them to gain job-ready skills needed to launch careers in IT Support, Data Analytics, UX Design, Project Management or Digital Marketing. After certification, participants will have the opportunity to kick-start their IT careers with internship opportunities in matching companies.

JA Ghana has engaged CSIR-INSTI to recruit and facilitate in-person sessions to learners engaged, subject to and based on the terms and provisions contained in a sub-Agreement contract signed by the two parties. The investigators would like to assess the impact and effectiveness of online career development as a research component of this project.

Objectives

1. Recruit participants from low socio-economic backgrounds, aged 18-35, in Greater Accra for the Google Career Certificate Scholarship Programme.

2. Provide comprehensive support to ensure that 100 enrolled participants earn their professional certificates on Coursera, including in-person and virtual assistance, career coaching, mentorship sessions, and connection to internship/job or project opportunities.

3. To assess the impact and effectiveness of online courses for practical skill acquisition and career development.

Materials and Methods

Learning would be carried out on the Coursera platform. Training and facilitation would be done physically. Data generated through forms would be mined for relevant information that would support or disprove the effectiveness of Online Career Development.

Results Achieved So Far

Proactive steps were taken to improve the learning rate of participants who were signed up on the various courses. These included the organisation of three boot camps with mentorship sessions and the awarding of some cash prices for participants who completed their courses within specific deadlines. As a result, the Institute recorded over 800% increase in participants completing their respective courses. In an attempt to understand learner's motivation for completion of online courses, CSIR-INSTI looks forward to revealing key measures that motivate learners on self-learning platforms.

Way Forward

Students' learning rates and progress would be analysed in relation to their profiles and correlations made to understand and unveil factors that could be leveraged to make online education more effective. The Institute looks forward to publishing the findings in a journal.

2.2.7 Physical Layer Key Generation for Secure Wireless Networks

Research Team:	Danquah, P. A. & Ahiadormey, R. K.
Start Date:	February 2023
Duration:	24 months
Sponsors:	CSIR-INSTI
Collaborating Institution:	None
Location:	CSIR-INSTI

Introduction

The broadcast nature of wireless networks means that eavesdroppers can easily compromise data security and privacy. In addition to traditional cryptographic techniques, Physical Layer Security (PLS) has been proposed to secure data transmission. Physical Layer Security is a technique of securing wireless networks by exploiting the physical characteristics of the wireless channel, such as randomness, fading and reciprocity. This project will investigate and develop a physical layer key generation scheme to improve the security of wireless networks.

Objectives

The objectives of this project are to:

1. Develop novel physical layer key generation schemes for wireless networks.

2. Implement novel physical layer key generation designs on the Software Defined Radio (SDR) platform for performance validation.

Materials and Methods

The programme is designed to achieve the outlined objectives of the project as enumerated in the following phases:

1. In Phase 1, a literature review of existing solutions related to the project will be conducted. This phase will also identify the software tools, evaluation metrics and implementation toolkits that are needed for the successful execution of the project.

2. Phase 2 will develop novel solutions to the previously outlined research problem. Phase 2 will follow the following steps: system modelling, problem formulation, solution design, and performance evaluation.

3. In Phase 3, a testbed based on SDR hardware will be implemented in a real-world wireless propagation environment. The SDR will be deployed for design validation and performance evaluation. The overall operation of the testbed will enable various insights into physical layer key generation.

Results Achieved So Far

Successfully purchased two communication devices.

Way Forward

The expected outcomes of the proposed project are:

1. Novel physical layer key generation design for wireless networks
2. Software-defined radio testbed for physical layer key generation for wireless networks

2.2.8 An Ant Colony Inspired Approach to Decentralised Data Processing for Load Balancing in IoT

Research Team:	Wilson, M., Boateng, K. O., & Nunoo-Mensah, H.
Start Date:	June 2021
Duration:	36 months
Sponsors:	CSIR-INSTI
Collaborating Institution:	KNUST
Location:	CSIR-INSTI & KNUST

Introduction

Nature's success in optimally solving problems with high complexity, extreme diversity and dynamism have been the backbone for a class of meta heuristic optimisation techniques classified to be bio-inspired. Bioinspired algorithms have been studied extensively in past decades for optimisation in computing. The stochastic nature of bioinspired algorithms presents an advantage over their deterministic counterpart approaches when size and complexity increases. In this field, the distributed and indirect interaction among social insects (who live in colonies) in solving complex problems have been studied and adapted extensively for the design and implementation of distributed swarm-based intelligence systems in computer science. The coordination of activities of these social insects have been studied to be both flexible and robust. These two features respectively allow their adaptation to dynamically changing situations while keeping the colony functioning even when some insects refuse to perform their tasks.

The absence of a centralised processing unit in Ant Colony Optimisation is leveraged to solve the load balancing problem in mobile edge computing. Adapting ACO for the above optimisation problem requires that artificial ants are defined and the optimisation problem formulated in a way that can be used by the defined artificial ants to build a solution.

Objectives

1. Design load balancing algorithms to ensure that some node resources in a collaborative computational network are not overburdened while at the same time, other nodes are relatively idle.

2. Design load balancing algorithms to ensure that local node activities are not adversely affected by global tasks during collaborative computing.

Materials and Methods

The load balancing optimisation explored in this work adopts the ACO following the steps outlined below:

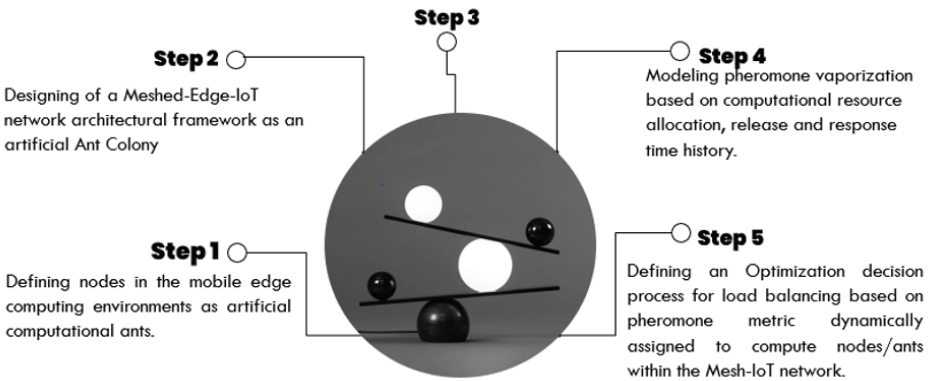

Fig 2.1 Modeling of pheromone as an ant computation capacity and availability metric

Results Achieved So Far

With response to Ericsson's 2020 report, the project is currently at the point where if the available collaborative computational resources in the IoT network is capable of handling the data processing task, then the latency optimisation problem reduces to a task offloading problem with the goal of optimally decentralising computational task and offloading them to end-user nodes in a serverless computing IoT environment established by the local area network where the task originates. To this effect, this section of the paper discusses the use of an Ant Colony inspired orchestration for the design of

a decentralised serverless computing paradigm for stateful task offloading among end-user nodes in critical IoT environments. A self-organised critical IoT implementation is designed with a novel pheromone-inspired protocol ("p-i protocol") that works to achieve communal collaborative data processing using resources derived from individual IoT nodes and serverless interaction between these nodes in an otherwise disjointed IoT setup.

A pheromone-inspired protocol has been proposed as a six-step decision process, aiming to maximise the utilisation of available resources in the closest reachable IoT network for task processing. This protocol ensures that tasks are handled either within their originating network or in the nearest network with adequate resources, while preventing a scenario where certain nodes become overwhelmed while other capable nodes in the same network remain underutilised. The figure below shows the process flow for our proposed p-i protocol.

Fig 2.2 Process flow for proposed p-i protocol.

Way Forward

Final publication has been submitted to the IEEE-Internet of Things journal awaiting reviewer's feedback.

2.3 Science and People

2.3.1 Dissemination Pathways for Scientific Research Findings; Evidence from the perspectives of CSIR, Ghana Scientists

Research Team:	Odonkor, E., Manteaw, S. A., Ampofo-Addo, A. S. & Dusi, M.
Start Date:	January 2023
Duration:	24 months
Sponsors:	CSIR-INSTI
Collaborating Institution:	None
Location:	All CSIR Institutes in Ghana

Introduction

Technologies generated from research play a key role in the economic development and growth of countries through application in various sectors of their economies. With technological progress, production of goods and services become more efficient leading to prosperity. Developing countries need technologies to advance their economic growth and Ghana is no exception to the growing global concerns for economic development. The challenges facing the country's economy are many. The myriad of challenges confronting the global economy presently calls for a robust application and implementation of technological innovations to support economic growth in a country like Ghana. Over the years, the scientific community has played an increasingly important role in national development. They develop the economy through research by providing information in areas that have already been researched into, and new areas that can be researched. In this sense, the production, management and dissemination of scientific data and information are very critical in scientific research.

In most Third World countries, a lot of knowledge remains locked up and inaccessible to those who require it. The result is the stagnation in growth of developing countries'

economies due to lack of information on much needed modern technologies for growth. Apart from that, there is a huge gap between research and application of research outputs. It is important to bridge the gap between the vast information and knowledge generated through research (output knowledge) and the needs of users. Meanwhile empirical evidence shows that technologies generated from research will continue to be the most important drivers of economic growth in most countries. However, there remains a good deal of predictive and advisory research outputs that have over the time remained as publications in journals and databases. Therefore, there are concerns in many countries, among governmental and other sponsors of research and development programmes, over the gap between research and practice.

Users need information from different disciplines and the evidence shows that such scientific information is generated from universities and research institutions. The successful transfer of technology from research organisations to end users require visibility of the research organisation and use of relevant tools to communicate to users through relevant messaging channels. The more people know about the good work done by research organisations, the more support these research organisations will receive and the more impact they can have. With the rapid development of Information and Communication Technologies (ICTs), data and information can be effectively generated, stored, analysed, disseminated and used for sustainable development in Ghana.

Over the years so much research has been undertaken in various sectors by scientists of the CSIR, most of which are not accessible to end users. The main weakness is the lack of communication between researchers and research institutions including universities and the targeted end-users. This gap has become a national set back to development. The result is a lack of adequate knowledge and information management, resulting in a huge gap between research (outputs) and end users. This study seeks to examine the effectiveness of the dissemination methods used by research scientists of the CSIR to reach end users.

Objectives

Determine the channels used by researchers of the CSIR for disseminating research outputs;

1. Identify the factors militating against research output dissemination by researchers of the CSIR
2. Identify the factors that influence research efforts of researchers of the CSIR
3. Assess the pathways for disseminating research outputs in terms of strengths and control in the institutes of the CSIR.

Materials and Methods

Study Area

The study involved all the CSIR research staff in all the 13 CSIR research institutes across Ghana. There are (13) thirteen research institutes that work together to carry out the CSIR's mandate, they are;

Building and Road Research Institute (BRRI), Food Research Institute (FRI), Institute of Industrial Research (IIR), Water Research Institute (WRI), Crops Research Institute (CRI), Forestry Research Institute of Ghana (FORIG), Oil Palm Research Institute (OPRI), Soil Research Institute (SRI), Plant Genetic Resources Research Institute (PGRRI), Savanna Agricultural Research Institute (SARI), Science and Technology Policy Research Institute (STEPRI), and the Institute for Scientific and Technical Information (INSTI) .

One essential resource that is crucial to the development of a country is information. Information accessibility drives progress in scientific and technical development.

The Institute for Scientific and Technological Information is the CSIR's Central Reference and Research Library (INSTI). Through its printing and scientific publishing sections, INSTI is able to properly repackage Scientific and Technical Information (STI) for distribution. It works in tandem with the CSIR's institutional libraries to gather, process, store, retrieve, and distribute scientific and technical data for the nation's socio-economic development.

Research design

This study adopted a quantitative research design, employing mainly survey a method of enquiry.

Sampling

The total number of the research scientists for the CSIR was 580 which was used as the population. The sample size is estimated using the following information;

$n = \frac{N}{1 + N(e)^2}$ where **n** is the sample size **N**, is the population size and **e** is the margin of error, assuming 5 percent margin of error and 95 percent confidence level, the sample size is computed. The sample size determined was 237 which was distributed proportionately across the institutes as shown in table 2.1

Table 2.1

Sample size determination for CSIR

List of Institutes	Total No. of Research staff	Proportion	Distribution/ Institute
CSIR-ARI	50	0.09	20
CSIR-BRRI	41	0.07	17
CSIR-CRI	95	0.16	39
CSIR-FRI	30	0.05	12
CSIR-FORIG	57	0.10	23
CSIR-INSTI	24	0.04	10
CSIR-IIR	40	0.07	16
CSIR-OPRI	33	0.06	13
CSIR-PGRRI	20	0.03	8
CSIR-SARI	44	0.08	18
CSIR-STEPRI	14	0.02	6
CSIR-SRI	32	0.06	13
CSIR-WRI	100	0.17	41
Total	**580**	**1.00**	**237**

Method of data collection

The data for the studies were obtained through online questionnaire administration to research staff of the CSIR all over Ghana. Desk studies were conducted to collect additional data. Data were collected from 237 research staff spread proportionately across the various institutes and the simple random sampling technique was used in selecting the respondents

Data Analysis

Data analysis software SPSS would be used to analyse the data collected. The quantitative survey data would be analysed using descriptive statistics such as frequency distributions, cross-tabulations (chi-square), and regression analysis to determine relationships between the variables. The results would be presented in tables and graphs.

Results Achieved So Far

Data collection is on-going.

Way Forward

Continuation of data collection through interviews.

3.0 PROGRAMMES AND ACTIVITIES

3.1 Communications Division

Mandate: To research and develop tools, equipment and communication systems aimed at solving electronics and communication problems for national development. The Communications and Electronics Divisions work in close collaboration with other divisions to execute programmes and activities.

Grow With Google Scholarship Programme/ Consultancy Project (Sub Grant to the CSIR-INSTI Makerspace)

The year 2023 saw a continuation of the sub-grant agreement between Junior Achievers (JA) Ghana and CSIR-INSTI on the Grow with Google Scholarship Programme, which aims to train youth between 18 and 35 years in Digital Marketing, Cyber Security, Data Analytics, IT Support, Project Management and UI/UX Design. The training is carried out online via the Coursera platform. Statistics from the previous year demonstrated that the participant pool has a gender ratio of 1:2 (female to male) with diverse educational and professional backgrounds. Geographically, the Greater Accra Region stands out, and urban participation is robust. The marketing approach used effectively targeted skill-focused learners through email campaigns and partnerships, supported by engaging visuals. Notably, a 60.77% completion rate for pre-survey forms and 37.63% active course participation showcase tangible outcomes. Qualitative feedback underscores participant engagement and the programme's perceived value in skill development. Below is an overview of details shared with stakeholders during the second cohort inception meeting held on 18th August 2023:

Geographic Distribution

1. Regions represented: The Greater Accra Region had the highest registration numbers.
2. Urban participants measured in the high percentile.

Marketing and Publicity Prior to Recruitment A. Marketing Strategy Overview

1. Target audience: Individuals seeking to enhance their digital skills for career advancement.
2. Value proposition: Offering self-paced, high-quality online training programmes and courses.
3. Key messaging and branding: Emphasising the opportunity to learn in-demand skills for the digital age.

Marketing Channels and Activities

1. Email campaigns: Sent personalised invitations to those who expressed interest in the initial cohort.
2. Partnerships and collaborations: Collaborated with Heritage University College to reach students and promote the programme.

Recruitment Materials

Graphics and visuals: Designed eye-catching graphics for social media posts and website banners from the initial cohort.

Results and Impact of Marketing and Publicity – Quantitative Metrics

1. Total Registered Participants: 417
2. Participants Who Fully Completed the Pre-survey Form (as at July 31st, 2023): 253 at a Completion Rate of 60.77%
3. Participants Actively Taking Their Registered Course (as at August 9th, 2023): 157 stands at 37.63%

Fig 3.1 Age Distribution

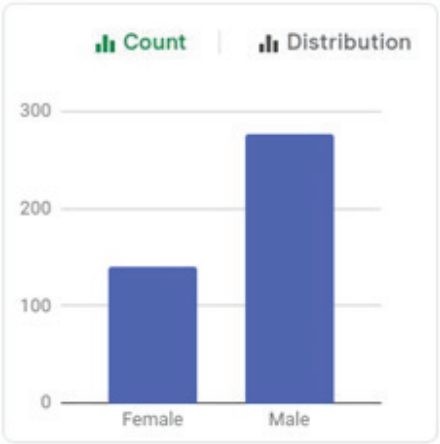

Fig 3.2 Gender Distribution

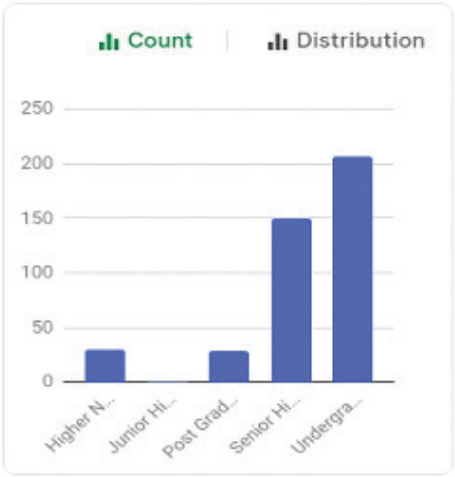

Fig 3.3 Educational Distribution

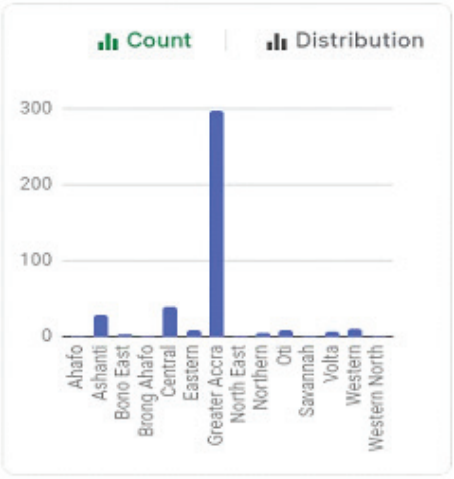

Fig 3.4 Regional Distribution

During the year, student participation increased by over 800% and learning rate improved as a result of new measures implemented. These measures included the organisation of three boot camps with mentorship sessions, as well as the award of cash prices for participants who successfully completed courses within specified deadlines. Additionally, a research component of the project was introduced to assess the impact and effectiveness of online career development.

CSIR Online Quarterly Report Management System and Online Appraisal Management System

Development of the Online Reporting Management Platform which commenced in 2021 was completed during the year, and would be piloted at the institute-level in 2024. The system captures information related to Research and Development, and Activities from Divisions for further compilation and submission to management. In addition, the system has been diversified to include an Online Appraisal Management portion, which eliminates the paperwork involved in appraising the performance of staff under various categories of the CSIR. Development of the system is 75% complete with interactive features permitting dialogue between subordinates and supervisors.

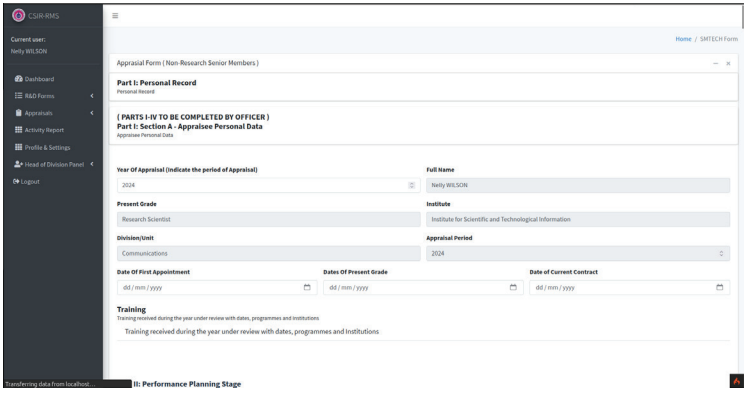

Fig. 3.5 Interface of the Online Quarterly Report

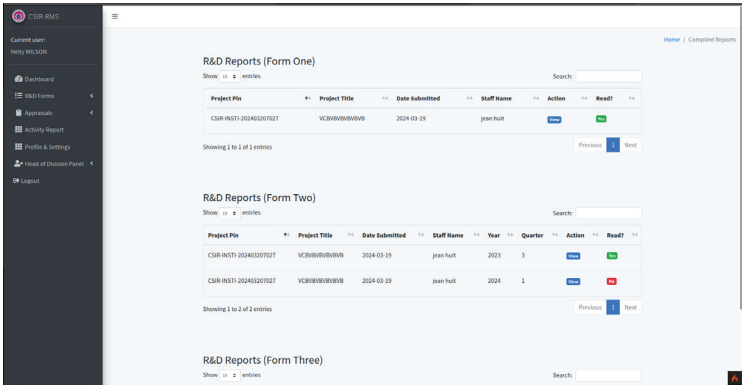

Fig. 3.6 Interface of the Appraisal Management System

3.2 Electronics Division

Mandate: To research into the development of next-generation electronics tools aimed at solving electronics and communication problems for national and social-economic development.

CSIR SOFTLAB - Partnership with Mirza Ghulam Qadir Shaheed I.T Research Lab & Centre, UK

CSIR SOFTLAB is a visionary initiative with the goal of becoming a national facility for software testing services in Ghana. Driven by the aspiration to set industry standards for software deployment excellence, the lab aims to empower professionals and students with cutting-edge knowledge and skills in the development of software that meet global benchmarks. With a strong emphasis on quality assurance and a desire to deliver the right solutions without compromising on quality, CSIR SOFTLAB is poised to make a significant impact on the software landscape in Ghana. Leveraging the expertise and resources of the Mirza Ghulam Qadir Shaheed I.T Research Lab & Centre (MGQS), the lab has the opportunity to establish itself as a prominent player in the software testing arena and contribute to the growth and advancement of the industry in the country and beyond.

The vision for CSIR SOFTLAB is to emerge as a national facility for software testing services and setting industry standards for excellence in the deployment of software in Ghana. Additionally, the Lab will strive to become recognised for delivering accredited and top-notch software testing services and training courses that empower professionals and students with cutting-edge knowledge and skills in the development of software that meets global standards.

Justification - "if it's worth launching, it must be tested", is to give clients the confidence they need in the use of software applications. The CSIR SOFTLAB will be established by experienced software testing consultants with a passion for Quality Assurance and a desire to build a national facility that delivers the right solution with no compromise on quality. Initial steps of its establishment will work towards getting the Lab to be ISO 9001 Quality Management Standard accredited by 2025.

The Mirza Ghulam Qadir Shaheed I.T Research Lab & Centre (MGQS) is a global technology solutions provider that draws expertise from world renowned institutions to support IT projects in different countries for public good. The CSIR SOFTLAB has been presented with the opportunity to leverage the significant strengths, resources and expertise of MGQS volunteers, in an attempt to establish and resource the SOFTLAB as a national facility for software testing services, setting industry standards for excellence and empower professionals and students with cutting-edge knowledge and skills in the development of standard software.

Phase One Objectives:

1. Define in-house methodologies and frameworks for the designing and implementing tailored solutions that accurately test software against its set of unique requirements as well as cutting-edge global standards.
2. Acquire ISO 9001 Quality Management Standard accredited by 2025
3. To train in-house staff to acquire International Software Testing Qualifications Board Certifications
4. Provide commercial software testing services for SMEs
5. Provide free software testing services for students in Ghanaian Universities
6. Partner with MGQS in the training of young Ghanaians and professional in developing software to meet standards

Administrative Exchange Programme between Ghana and North Rhine-Westphalia-Germany.

The Head of the Electronics Division participated in an Administrative Exchange Programme between Ghana and North Rhine-Westphalia-Germany. The programme offered valuable opportunities for knowledge sharing and collaboration in addressing global agriculture related challenges. Interactions were held with experts in selected organisations in Germany with possible future collaboration opportunities. The 10-day programme was held from 17th to 27th September 2023. The delegation from Germany would be received by the Electronics Division of CSIR-INSTI in February 2024 to firm up possible collaborations and pin down the way forward.

Excellence in Agronomy

The Excellence in Agronomy programme, through Lump sum Funding Agreement No: C23ROM175, aims to support CSIR-INSTI in enhancing productivity and quality in targeted farming systems by 2030. The primary focus is on developing digital advisory tools for smallholder households, women, and young farmers. The project, being carried out with the Alliance of Bioversity International and CIAT (ABC), aims to create agro-advisory tools, including a digital cropping calendar and bundled agro-advisory on the Excellence in Agronomy Advisory Hub. This developed calendar guides farmers and extension officers year-round, considering region-specific parameters and crop types. The process involves accurately determining rain onset, validated content gathering, and generating customised calendars.

The mobile-compatible web app provides tailored guidance, optimising resource use, increasing productivity, and aiding decision-making. Users access contacts for input, insurance, and extension services, with prompts on risks and mitigation steps at each cropping stage. The system empowers farmers, promotes sustainable agriculture, and enhances livelihoods, aligning with the Excellence in Agronomy program's goals. The advisory tool is accessible at https://eiahub.org/main/Croppingcalendar.

Uploaded content was obtained via a data collection workshop organised at the Anita Hotel, Ejisu in the Ashanti Region on the 31st of August to 1st of September 2023. This exercise brought together expertise and stakeholders to ensure the right content is mobilised and validated for use in the development of the key deliverable under the contract. The specific objective of the workshop was to collaborate and harness the collective expertise of scientists and experts to validate and make input to agronomic information and content.

MAG 2023 Deliverables

In accordance with the MAG 2023 work plan, an e-learning portal – Farm Academy, was developed. The portal was developed to consolidate practical and demonstrable agricultural technologies as well as existing training programmes under one umbrella. Video content with voice overlay has been developed for the sharing of knowledge on practical applications of safe technologies and best practices. It is envisaged this setup

will increase access to research output, improve food quality/safety, and also reduce the environmental impact of agriculture. The portal is available for access via https://learn.csirgh.com/, they include courses as outlined in table 3.1.

Table 3.1

Collaborating institutions for CSIR Farm Academy developed in 2023

Nº	Topic	Collaborating Institution
1	Fall armyworm management	CABI
2	Mulching	AICCRA
3	Indigenous microorganism technology	CSIR-ARI
4	Fish farming	CSIR-WRI
5	Soil fertility management	CSIR-CRI
6	Yam propagation and the minisett technique	CSIR-CRI
7	Managing pathogens in yam production	CSIR-CRI
8	Pest management – maize & cowpea	CSIR-CRI
9	Crop rotation & intercropping	CSIR-CRI

Discussions are ongoing to monetize some courses and also bundle the courses into insurance packages of some identified private sector players.

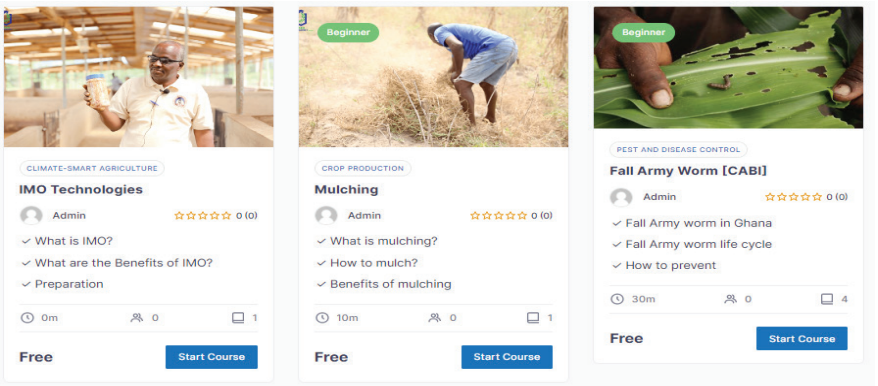

Fig. 3.7 Courses hosted on the portal as of April 19, 2023

Fig. 3.8 Content creation with CSIR-Animal Research Institute -Koforidua

Fig. 3.9 Content creation with CSIR-Water Research Institute -Akosombo

Fig. 3.10 Content creation with CSIR-Water Research Institute -Akosombo

Fig. 3.11 Content creation with AICCRA and ESOKO team

Fig. 3.12 Content creation with KOPEA Experimental Rice Farms

Fig. 3.13 Monitoring and Evaluation with CSIR MAG Secretariat 2023

The completion of this deliverable successfully draws the curtain on the MAG project. Table 3.2 details all achievements chalked under the project.

Table 3.2

Major achievements under the MAG project

Output	Target Beneficiaries	Actual achievement	Status
Agritech Advisor Mobile and Web App as quick reference for farmer's basic information needs.	1. Public and private Extension agents 2. Farmers 3. Researchers	The platform has been successfully developed, deployed and is accessible at this link < https://agritech.csirgh.com/ > STATISTICS ON USAGE 146 Answered Questions 963 Visitors 662 Unique Visitors Monthly	Completed
An online directory that allows experts and researches to continually update value chain actors on new findings ready for adoption for modernising agriculture	1. Public and private Extension agents 2. Farmers 3. Researchers 4. Agri-businesses 5. Policy-Makers	The platform has been successfully developed, deployed and is accessible at this link < https://technologies.csirgh.com/ > STATISTICS ON USAGE 309 Technologies made accessible online 20 Visitors 17 Unique Visitors Monthly	Completed

A digital service that collects, preserves, and distributes digital materials and reports from researchers of the CSIR.	1. Researchers 2. Policy Makers 3. Students of Agric-Colleges	The platform has been successfully developed, deployed and is accessible at this link < https://agritech.csirgh.com/ > STATISTICS ON USAGE 2,255 Documents available in 9 collections 20 Visitors 17 Unique Visitors Monthly	Completed
An e-learning platform for farmers and AEAs that provides accessible and comprehensive training to improve agricultural practices.	1. Public and private Extension agents 2. Farmers 3. Researchers 4. Agri-businesses 5. Policy-Makers 6. Ghanaian Youth	The platform has been successfully developed, deployed and is accessible at this link <https://learn.csirgh.com/ > STATISTICS ON USAGE 9 Online Courses rolled out 300 Visitors 120 Unique Visitors Monthly	Completed
Kuafo Marketplace Web & Mobile Apps as dedicated e-commerce platforms for selling farm produce	1. Farmers 2. Input Suppliers	The platform has been successfully developed, deployed and is accessible at this link < https://kuafo.csirgh.com/ > STATISTICS ON USAGE 310 Products currently advertised 432 Active Platform Users 278 Average of monthly visits	Completed

AEAs and Farmers trained on how to use the compendium of tools developed under the Digital Agricultural innovation Hub	1. RELCS (Kumasi, Wioso, Ho, Koforidua, Techiman, Goaso, Bolgatanga, Cape Coast) 2. FBOs (7 Groups with 30 participants at each training) 3. AEAs (Kumasi, Kumasi, Cape Coast)	~ 900 trainers have been trained	Completed

National Entrepreneurship and Innovation Programme (NEIP) Challenge

The Electronics Division supported the NEIP's National innovation challenge by mentoring the selected participants. Additionally, the Division assisted in the preparation of the judge score-sheets and development criteria for judging the challenge. The Division also served on the panel of judges during the final adjudication.

3.3 Geospatial and Information Science Division

The Geospatial and Information Science Division (GISD) consists of the Scientific Information Management Section (SIMS) and the Geographic and Information Systems Section (GISS).

3.3.1 Geographic Information Systems Section

Mandate: To collect data for the design and construction of Thematic Maps of Ghana at the national, regional and district levels. The Section is also to answer to the need of clients for special or customised maps and to use existing capacities to train individuals and institutions on techniques of spatial data documentation using Geographic Information.

Mapping Activities

1. Regional Population Density Mapping

The 2021 population census data was used to generate regional population density maps for 16 (sixteen) regions.

i. Upper West
ii. Upper East
iii. North East
iv. Northern
v. Savanna
vi. Oti
vii. Western
viii. Western North
ix. Ahafo
x. Ashanti
xi. Bono
xii. Bono East
xiii. Central
xiv. Eastern
xv. Greater Accra
xvi. Volta

2. Regional land use / cover database development

There was a revision of the draft technical report on the regional land use and land cover database. Work on this database has been completed.

3. Mapping of CSIR Institutes

A map of the location of all CSIR Institutes was produced by the GISS.

Fig. 3.14 A map of the locations of CSIR institutes

4. CSIR Footprint Map

A map of Ghana showing CSIR footprints across the country was produced for the CSIR Head Office. This map contained the location of all CSIR Institutes, Field Stations, CSIR Plus Offices, among others.

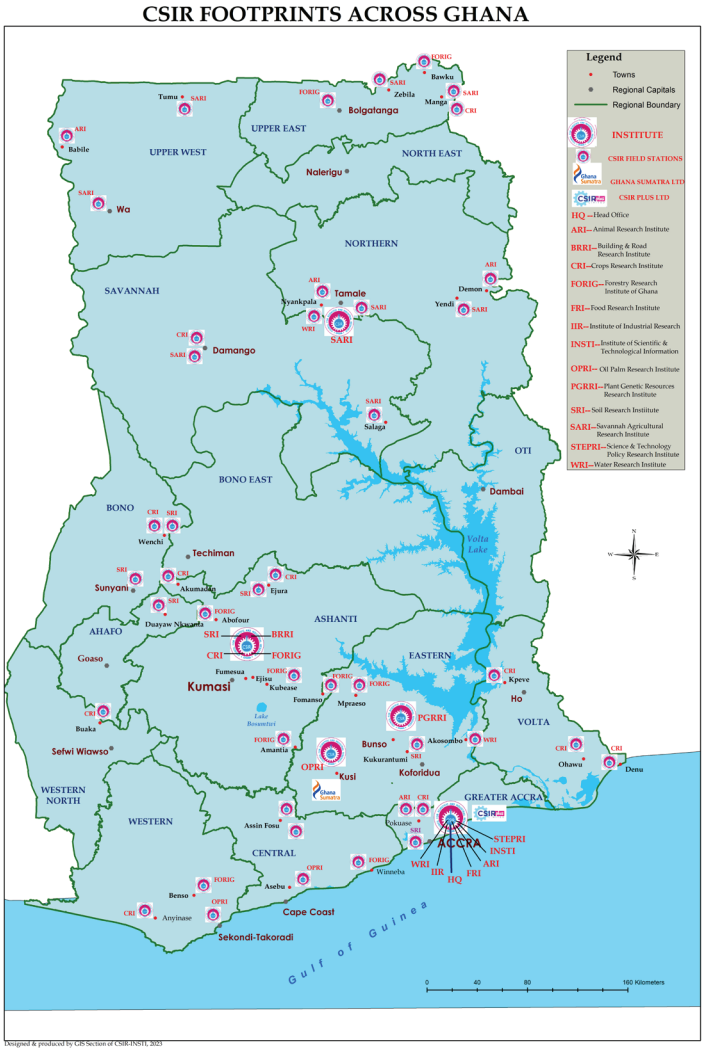

Fig 3.15 CSIR Footprints map

5. Ghana Districts (Geospatial) Database:

The creation of a database for all MMDA's in Ghana continued throughout the year. The database contains the following information;

i. Settlements,

ii. Rivers,

iii. Road network

iv. District boundaries

v. Contours

The following MMDA's databases and base maps were created with draft maps available.

a.	Western region	-	14 MMDA's
b.	Western North region	-	9 MMDA's
c.	Ashanti region	-	43 MMDA's
d.	Central region	-	22 MMDA's
e.	North East region	-	6 MMDA's
f.	Greater Accra region	-	29 MMDA's
g.	Ahafo region	-	6 MMDA's

3.3.2 Scientific Information Management Section

Mandate: To provide scientific and technological information services for the CSIR and analogous institutions, learned and professional associations and societies, the industrial sector, students and the general public. The Section has three sub-sections viz: the Collection Development, Cataloguing and Classification, and User Services technical sub-sections.

3.3.2.1 Collection Development Sub-section

Responsibilities of the Collection Development sub-section include acquiring books, collecting data, print and electronic resources of science and technology information and other science materials for the library. It is also in charge of providing specific and general guidelines for the selection and acquisition of new materials through purchases, exchanges, soliciting or donations, legal deposit or through subscription and collaboration. The sub-section feeds all databases created by the Scientific Information Management Section.

3.3.2.2 Cataloguing and Classification Sub-section

The Cataloguing and Classification Sub-Section is responsible for the processing of the materials acquired for the library and making them ready for display and use by clients. This is done by way of the physical description of the materials and content description. The Library Thing is a social cataloguing web application currently used by the section for storing and sharing book catalogues and various types of book metadata. Statistics of materials received during the year are captured in Table 3.3.

Table 3.3

Statistical summary of materials received in 2023

Type of Material		Nº of Copies Received	Percentage
Theses		97	4.48
Journals		81	3.74
Annual Reports		19	0.88
Books		2	0.09
Newspapers	Daily Graphic	841	38.83
	Ghanaian Times	838	38.69
	Weekly Spectator	144	6.65
	Weekly Mirror	144	6.65
Total		**2166**	**100**

3.3.2.3 User Services Sub-section

The major activity of the User Service Subsection is the identification and retrieval of information to meet the demands of clients. Books, periodicals, abstracts, newspapers, and reference materials are used to deliver these services. For scientists, consultants, and students, information is manually retrieved from magazines, abstracts, theses, newspapers, and reference materials. Additionally, internet searches for clients are conducted utilising search engines such as Google, Dogpile, Yahoo, and Yandex.

The section also uses foreign databases to retrieve information for clients. These sources are; Access to Global Online Research in Agriculture (AGORA), Health Inter-Network Access to Research Initiative (HINARI), Online Access to Research in the Environment (OARE), Journal Storage, African Journals Online (AJOL), PubMed, Directory of Open Archive Journals (DOAJ), Proceedings of the National Academy of Sciences (PNAS), Bioline International, EBSCO, JSTOR.

The section also uses The Essential Electronic Agricultural Library (TEEAL) distributed by the TEEAL Project at Mann Library, Cornell University. The User-service also offers services such as Referral services, Research Advisory, Selective Dissemination of Information (SDI), Current Awareness and Question and Answer.

3.4 Printing and Publishing Division

Mandate: The Printing and Publishing Division is mandated to provide printing and reprographic services for the production of scientific, technical literature and other printing services and products to support the socio-economic development of the country. Activities of the Division include;

- Designing, receiving and generating quotations for clients.
- Printing, collating, folding/ binding and delivering jobs to clients.
- Editing, typesetting and proofreading of manuscripts submitted by researchers for publication.
- Writing reports, technical correspondence and distribution of print journals.

3.4.1 Printing Section

The section executed the following internal and external designing, editing, typesetting and printing jobs:

Fig. 3.16 Some designs by the CSIR-INSTI Printing Section 2023

Table 3.4

List of main projects implemented by printing section

Nº	Client	Description of Job
		CIE Certificates
	CSIR – CCST	Certificates CCST – CIA
		Certificates for research methods
	CSIR – FRI	2022 Annual Report
		Flags – Ghana flag and CSIR flag
		Letterheads
		Programme - Swearing in ceremony
		Branded envelopes
		2024 Calendars and diaries
		Citations – Retirement and best worker
		Programme: Annual Thanksgiving Service
	CSIR – Head Office	Programmes: CORAF
		Flag: CORAF
		Backdrop banner
		Dummy cheque
		Call Cards – Director General
		Call Cards – Deputy Director General
		Book – Strategic plan
		Corporate Brochure
		Call Cards – Board Chairman
		CSIR advert for Daily Graphic
		Retirement citations
		Letterheads
	CSIR – INSTI	Front signage
		Folders
		Flexy banner
		2022 Annual Report

CSIR – PGRRI	2022 Annual Report
CSIR – SARI	2021 Annual Report
	2022 Annual Report
CSIR – OPRI	Branded folders
	Plaque
CSIR – WRI	Handouts/ Policy briefs
	Scientific Posters/ Handouts
Private person	Book: Corruption in Ghana: The Musings of a village boy

3.4.2 Science Publishing Section

The Science Publishing Section is mandated to publish the *Ghana Journal of Agricultural Science* (GJAS) and *Ghana Journal of Science* (GJS) as well as other S&T literature emanating from the national and international scientific community. It is also mandated to conduct R&D projects aimed at aiding policy decision-makers, the scientific publishing industry, planners, researchers and the general public. GJS and GJAS are Open Access Journals, distributed under the terms of the Creative Commons (CC) License [CC BY 4.0]. Guidelines for Authors and templates for the Ghana Journal of Agricultural Science and Ghana Journal of Science can be downloaded from the CSIR-INSTI website via the respective links: http://insti.csir.org.gh/gjas.php and http://insti.csir.org.gh/gjs.php

Ghana Journal of Agricultural Science (GJAS established in 1961)

The Ghana Journal of Agricultural Science published 12 articles in GJS Vol. 58 (1) (2023) and 16 articles in GJS Vol. 58 (2) (2023) on the AJOL website. Details of published articles are given below:

Table 3.5

Articles published in Vol 58 (1) (2023) of the GJAS

Nº	Title	Authors
1	An inventory of birds and extent of damage to rice farms at the Kpong Irrigation Dam in the Lower Volta Basin, Ghana	E. D. Wiafe
2	Fabrication and performance evaluation of a wooden cabinet dryer for value addition of fruits for micro-, small and medium-scale enterprises (MSMEs)	C. Tortoe J. Ampah P. T. Akonor E. S. Buckman S. Nketia
3	Can varying photoperiod regimes alter the growth response, behaviour and physiology of *Clarias gariepinus*?	O. C. Ojelade O. S. Iyasere S. O. Durosaro O. A. Akinde O. Akande L. M. Oladejo D. R. Sanusi O. A. Sotunde
4	Testicular and epididymal anatomy and spermatozoa reserves of rabbit bucks fed *Moringa oleifera* leaf meal-based diets supplemented with mixtures of garlic, ginger or black pepper	A. A. Mohammed G. T. Iyeghe-Erakpotobor D. Zahraddeen P. P. Barje F. U. Samuel
5	Correlation coefficient of live weight and body measurements of extensively reared West African Dwarf goats in south west zone of Nigeria	A. Tella C. A. Chineke O. O. Jacob

6	Warehouse receipt system: A shift to improve maize marketing in Ghana	N. K. Safo R. M. Al-Hassan H. A. Somuah A. A. Boakye I. S. Egyir
7	Risks Assessment of Copper (Cu), Lead (Pb), Mercury (Hg) and Zinc (Zn): A case study of *Tilapia guineensis* in Lagos Lagoon	A. O. Ajibare O. O. Loto
8	Evaluation and improvement of the health status of farmer-saved okra (*Abelmoschus esculentus* (L.) Moench) seeds in the Ashanti Region of Ghana	P. Cobbinah C. K. Kwoseh
9	Analysis of the consumption patterns of cassava food products amongst rural households in Imo State, Nigeria	C. C. Apeh O. P. Ugwuoti A. C. Apeh
10	Plant parasitic nematodes associated with oil palm trees in three regions of Ghana	H. Lutuf F. K. Ablormeti J. Obeng S. T. Nyaku F. Abdulai A. M. Eddy-Doh E. K. Dery
11	Incidence, diversity and distribution of Fusarium wilt pathogens of eggplant in some major growing areas of Ashanti, Eastern and Volta Regions of Ghana	E. O. Owusu C. K. Kwoseh E. Osekre R. Akromah
12	How consumers' motivations and perceptions shape consumption of domestic products in COVID-19 era: A case of poultry meat in Ghana	W. Quaye C. Asante-Addo G. Akon-Yamga M. Yeboah N. K. Safo

Table 3.6

Articles published in Vol 58 (2) (2023) of the GJAS

Nº	Title	Authors
1	Consumer awareness of polycyclic aromatic hydrocarbon (PAHS) contaminants in smoked fish and factors influencing smoked fish consumption in Ado-Odo/Ota Local Government area of Ogun State	O. O. Ayodeji T. S. Oni V. A. Sanyaolu
2	Maize-groundnut intercropping to manage fall armyworm and improved crop productivity in smallholder farming systems	S. Yeboah P. Amankwaa-Yeboah M. B. Brempong J. Adomako C. Darko E. N. Tetteh A. Ibrahim S. A. Ennin
3	Safety and sensory quality of *wagashie*, a West African cottage cheese	A. B. Arthur M. Owusu P. T. Akonor E. J. S. Blessie A. Atter V. Appiah W. K. Amoa-Awua
4	Assessing the usefulness of the e-Agriculture programme in Ghana using the Technology Acceptance Model	S. Bekoe D. A. Ayoung P. Danquah

5	Productivity of onion (*Allium cepa* L.) as influenced by composted poultry manure and fishpond waste in an aquaponics-based food system	H. A. Dwamena K. Tawiah E. O. Danquah S. K. Darkey M. D. Asante C. O. Peprah T. Frimpong P. Marfo A. K. A. Serwaa P. Marno S. K. Amponsah K. Agyeman M. O. O. Asante A. Karim F. Frimpong
6	Adaptation to climate change among artisanal fishers around Lekki Lagoon, Nigeria: A gender analysis	W. G. Ojebiyi O. R. Ashimolowo O. J. Olaoye P. D. Abdulsalam-Saghir O. J. Soetan
7	Pre-harvest and post-harvest practices along the plantain (*Musa* spp. AAB) fruit value chain in Ghana that predispose them to ripening	D. O. Ofosu I. Before F. Martinson G. K. Frimpong I. K. Asare B. Darfour
8	Agronomic attributes of cucumber (*Cucumis sativus* L.) as influenced by time of poultry manure application in Abia State, South East, Nigeria	A. U. Akpan J. N. Okamigbo

9	Demographic characteristics of farmers and the effectiveness of disseminating information on agriculture in Ghana	P. S. Osei-Kofi E. E. Badu P. S. Dadzie J. Bandanaa
10	Assessment of women involvement in artisanal fishery enterprises in Lagos State, Nigeria	O. P. Oyetade O. J. Olaoye W. G. Ojebiyi I. F. Idowu
11	Agricultural markets integration and price transmission in West Africa: Evidence from a meta-analysis	S. Bekoe S. Ayeduvor P. M. Etwire
12	Efficacy of some plant extracts as a safe and sustainable management option for *Sitophilus zeamais* (Motschulsky) in stored maize	V. Sackey Y. V. Eziah E. O. Owusu M. Billah S. Addae
13	ICT-enabled agribusiness: case of female fresh fish marketers in coastal area of Ogun State, Southwest Nigeria	A. A. Obisesan O. Oduntan E. L. Adetola
14	Age effect on quality traits of breeder Japanese quail eggs	F. Kruenti M. A. Okai V. K. Lamptey G. Adu-Aboagye A. D. Oduro-Owusu B. Suurbesig B. Mewu
15	The influence of cropping system and soil amendment on the diversity and abundance of arthropods in cultivated cabbage and onion	C. A. Oseifuah K. O. Fening K. Afreh-Nuamah R. S. Anderson

16	Efficacy and profitability of insecticides and crop management practices in the integrated management of *Leucinodes orbonalis Guenée* (Lepidoptera: Crambidae) on garden eggs	D. A. Kotey A. Bosomtwe J. Siamey E. Acheampong M. N. Bissah R. Tetteh V. Nketiah E. Gyasi E. D. Boamah J. Bandanaa

Ghana Journal of Science (GJS established in 1968)

The Ghana Journal of Science published 7 articles in GJS Vol. 64 (1) (2023) and 8 articles in GJS Vol. 64 (2) (2023) on the AJOL website. Details of published articles are given below:

Table 3.7

Articles published in Vol 64 (1) (2023) of the GJS

Nº	Title	Authors
1	Adsorption performance of groundnut and sheanut shells biochars in ternary system of toxic metals	A. B. Duwiejuah A.-H. Abubakari Y. Amadu
2	Phenology, morphological, and anatomical characteristics of a stinkhorn mushroom in Ghana	G. T. Odamtten M. Wiafe-Kwagyan N. K. Kortei
3	Factors influencing the health seeking behaviour of persons who have diabetes in the Kumasi metropolis	V. Asante B. B. Gariba, E. Appiah-Brempong H. L. Sarpong

4	Phytochemicals and biological activities of *Tetrapleura tetraptera* seed extracts	J. Korang J. O. Owusu-Asante S. Ibrahim, E. Ofori J. Owusu
5	Implications of socio-cultural practices on fisheries management: a case of the bottom-set gillnet fishery in the central region of Ghana	M. Y. Ameworwor J. Aggrey-Fynn M. N. K. Clottey
6	Morphological and morphometric features of the common rustgill mushroom (*Gymnopilus penetrans*, (Fr; Fr) Murray) in Ghana	G. T. Odamtten M. Wiafe-Kwagyan J. Addo
7	Soursop botany, chemical composition and medicinal prospects: a concise review	E. A. Omere A. U. Osaigbovo A. T. Adekunle

Table 3.8
Articles published in Vol 63 (1) (2022) of the GJS

№	Title	Authors
1	Effects of broodstock sex pairing ratios and rest periods of the Nile tilapia *Oreochromis niloticus* on fry production	S. Addo E. N. A. Oblie C. P. Duodu S. K. K. Amponsah W. Sowah E. K. Asamoah
2	Nutritional composition, bacterial load and organoleptic quality of farm-raised catfish(*Clarias gariepinus, burchell* 1822) from the Dormaa Municipality, Ghana	S. Addo W. Sowah S. K. K. Amponsah K. Issifu E. K. Asamoah

3	Molecular screening of chewing sticks and sponges found on the Ghanaian local market for diarrhoea-causing microbes- a pilot study	S. Armoo G. Twieku E. Armah
4	*Diospyros crassiflora* (HIERN) surface and subsoil leaf litter decomposition pattern along a time gradient in a humid rainforest	I. B. Nsien A. N. Ejizu H. O. Okonkwo U. F. Akpan E. E. Ewonghoabasi
5	Willingness of Ibadan residents to plant trees to commemorate social events	O. A. Fasoro O. I. Ajewole R. A. Siyanbola
6	Variation in the intestinal morphology and biometric characteristics of *Sardinella aurita* and *Sardinella maderensis* at James Town in Ghana	C. L. Ayisi E. H. Alhassan W. Awuku
7	Nutrients, phenolics, fatty acids and mineral composition of Telfairia pedata (SIMS) hook seed kernels obtained from Kilimanjaro, Tanzania	M. N. Monica
8	Plastics management for job creation, a feasible and practical solution to the waste pollution and unemployment	B. Y. Antwi A. Ofori-Nyarko M. A. B. Animpong J. Koranteng

3.5 Internal Seminars

Internal Seminars on various subject matters were organised for staff. Details are captured in Table 3.9.

Table 3.9

Internal Training/Workshops 2023

Nº	Date	Topic	Resource Person(s)
1	26th Jan 2023	OMEKA Data Migration Training	Mr. John P. Awotwi Mr. Moses Dusi
2	2nd – 3rd March	Security	Mr William Akpakli
3	23rd May 2023	In-house seminar I	--
4	24th May 2023	Technical Report Writing	Dr. Richard Kofie
5	14th June 2023	Technical Report Writing for Senior Staff Promotions	Rev. Gilbert Nachim
6	3rd Oct. 2023	In-house Seminar II & Promotions Seminar	--
7	13th Dec. 2023	Wikipedia & Wikidata Training	Mr Atta Ampofo-Addo Mr. Emmanuel Yeboah Madam Harriet Bayel

4.0 ADMINISTRATION AND FINANCIAL ISSUES

4.1 Administration Division

The Administration Division supported the operation of the Institute through the implementation of directives, policies, rules and regulations of the Council.

4.1.1 Introduction of Deputy Director-General and Director of Finance

The newly appointed Deputy Director-General and Director of Finance paid a visit to the Institute on 20th February 2023 to formally introduce themselves in their new positions.

Fig. 4.1 Introduction of Deputy Director-General and Director of Finance 2023

4.1.2 Management of INSTI

- There was an eight-member Management Board governing the Institute for the year 2023. Management Board meetings were held on 6th April, 28th September and 19th December 2023.

- The eleven-member Internal Management Committee with Dr. Seth Awuku Manteaw; Director, as Chairman, saw to internal issues of the Institute for the

period. Meeting dates were 9th March, 25th May, 29th August and 5th December 2023.

- Additionally, staff durbars were held on 8th June, 30th August and 20th December 2023.

4.1.3 Staff Strength

The staff strength of the Institute as at 31st December 2023, stood at 80 with qualifications outlined in Appendix III. Categorical breakdown are as follows:

- 27 Core and 5 Non-core Senior Members
- 33 Senior staff
- 15 Junior staff

Gender distribution is indicated in Table 4.1

Table 4.1

Staff Strength: Gender Distribution

Category/Gender	Males		Females		Total
Senior Members	25	1 non-core	7	4 non-core	32
Senior Staff	21		12		33
Junior Staff	11		4		15
Total	**57**		**23**		**80**

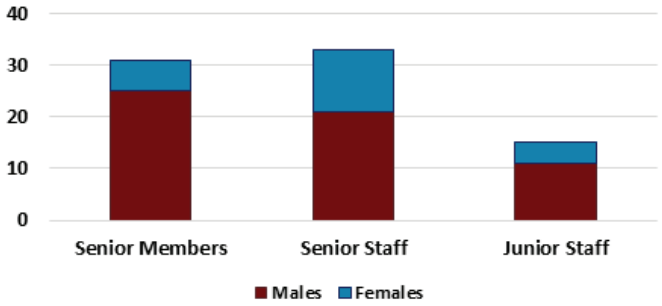

Fig 4.2 Staff Strength: Gender Distribution Graph

4.1.4 Staff Promotions

Eight members of staff were promoted during the year, details are found in table 4.2

Table 4.2

Promoted Staff

Nº	Name	Old Grade	New Grade	Effective Date
1	Danquah Paul Asante	Senior Research Scientist	Principal Research Scientist	01/01/2023
2	Asante Stephen Kwaku Jr.	Accountant	Senior Accountant	01/01/2023
3	Awanyo Dorothy	Administrative Officer	Senior Administrative Officer	01/01/2023
4	Kumiwa Doris	Administrative Assistant	Senior Administrative Assistant	01/01/2023
5	Abdulai Mamah Samiratu	Technical Officer	Snr. Technical Officer	01/01/2024
6	Awotwi John Paapa	Technical Officer	Snr. Technical Officer	01/01/2024
7	Ohene-Affih Benjamin	Technical Officer	Snr. Technical Officer	01/01/2024
8	Owusu-Ayirebi Yaw	Technical Officer	Snr. Technical Officer	01/01/2024

4.1.5 Staff Upgrade

Two staff members were upgraded during the year with details captured in table 4.3.

Table 4.3

Upgraded Staff

Nº	Name	Old Grade	New Grade	Effective Date
1	Ezekiel Narh Odonkor	Principal Technologist	Research Scientist	15/06/2023
2	Risikatu Lawal	Principal Accounting Assistant	Accountant	30/11/2022

4.1.6 Staff Transfer

- Ms. Anita Adusah, a Senior Administrative Officer, was transferred to the Institute from the Food Research Institute effective 1st November 2023.
- Ms. Esther Opoku, an Administrative Officer, was transferred from the Institute to Soil Research Centre effective 1st November 2023.

4.1.7 National Service Personnel

Twelve graduates were accepted as National Service Personnel at the Institute. They assumed duty on 1st November 2023. Details of their enrolment are captured in Table 4.4.

Table 4.4

National Service Personnel

Nº	Name	Institution	Division
1	Adjei Benedicta	University of Ghana	Electronics
2	Boakye Dorcas Agyapomaa	University of Ghana	Geospatial & Information Science
3	Dagadu Robert Kwame	University of Education	Printing & Publishing
4	Doku Jesse Edem Tettay	Methodist University College	Communications
5	Duku Ernest Kojo	Accra Technical University	Electronics
6	Dzie Solomon Kofi	Ghana Institute of Management and Public Administration	Communications
7	Kusi Kingsley	Takoradi Technical University	Printing & Publishing
8	Mingle Leslie Allotey	Takoradi Technical University	Printing & Publishing
9	Okai Priscilla	University of Cape Coast	Geospatial & Information Science
10	Oku Benjamin Nii Sackey	Takoradi Technical University	Printing & Publishing
11	Osei Samuel	Accra Technical University	Communications
12	Owusu-Banahene Kofi	University of Education	Communications

4.1.7 Study Leave

During the year, the following members of staff were granted study leave, as part of Council's policy on capacity building;

Table 4.5

Staff granted full-time/ partial study leave in 2023

Nº	Name	Programme/Institution	Duration
1	Prikutse Frank Lemdi	PhD Computer Science/ University of Cape Coast	3 years
2	Boateng-Agyenim Akua	PhD Marketing/ University for Professional Studies	4 years
3	Essegbey Buertey	PhD Economy and Management/ VSB-Technical University, Hungary	4 years
4	Folitse Patrick	MPhil Marketing and Strategy/ SD Dombo University	2 years
5	Azuma Victoria	MPhil Geography and Resource Development/ University of Ghana	2 years

4.1.8 Resignation

Two members of staff resigned from service of the Council:

- Ms. Maame Birago Kessey, Principal Technologist of the Electronics Division with effect from 1st June 2023.
- Mr. Charles Kulley, Junior Library Assistant of the Geospatial and Information Science Division with effect from 1st August 2023.

4.1.9 Retirement

Two (2) members of staff proceeded on retirement during the year;

- Mr. Benjamin Yao Folitse, Senior Librarian and immediate past Deputy Director of the Institute retired from service of the Council on 8th August 2023. Mr. Folitse joined the Council on 18th November 2002 as an Assistant Librarian. He was a key member of the GAINS project and served as Focal Person for the MAG programme between 2018 and 2023.

- Mr. Robert Abomoi, a Senior Security Officer, retired from service of the Council on 23rd October 2023. Mr. Abomoi commenced work at CSIR-NASLIC on 1st August 1994 as a Literate Helper. He was very instrumental in ensuring the security of the Institute.

4.1.10 Termination of Appointment

The appointments of two staff members were terminated – Messrs Simon Dunyo and Amos Gyekye, both were of the rank Security Assistant Grade I.

4.2 Accounts Division

Objectives of the Accounts Division for the year 2023 included;

- Capture financial transactions and prepare timely, accurate and transparent financial reports
- Ensure payroll duties are fulfilled
- Ensure adequate internal control procedures are put in place to safeguard the assets of the Institute
- Actively assist, support and guide management in making sound management decisions
- Take an active role in setting the annual budget, monitor the budget and do variance analysis.

4.2.1 Financial Statement for 2023

Total receipts for the year under review amounted GH¢8,334,093.61 and payments totaled GH¢8,324,712.55 with a surplus net receipt of GH¢9,381.06

The receipts are made up of salaries paid by GoG from the Consolidated fund amounting to GH¢7,133,530.70. Internally Generated Fund (IGF) amounted to GH¢388,098.45 and

Donor Funds of Gh¢812,464.46. The IGF activities included Printing, Hiring of facilities, and Consultancy.

Tables 4.6 and 4.7 capture a summarised Statement of Receipts and Payments and the Financial Position as at December 31, 2023

Table 4.6

INSTI Statement of Receipts and Payments for the year ended December 31, 2023

	ACTUAL 2023	ACTUAL 2022
	GH¢	GH¢
TOTAL RECEIPTS	8,334,093.61	6,121,840.13
TOTAL PAYMENTS	8,324,712.55	6,023,905.71
EXCESS/(DEFICIT)	9,381.06	97,934.42

Table 4.7

Summary State of Affairs as at December 31, 2023

	2023	2022
CURRENT ASSETS	875,115.81	594,667.73
NON-CURRENT ASSETS	375,931.94	175,680.65
LIABILITIES	509,039.59	271,960.56
NET ASSETS/(LIABILITIES)	742,008.16	498,387.82
NET WORTH	742,008.16	498,387.82

APPENDIX A: Publications

Refereed Journal Papers

Amofah K., **Dziwornu M. G.**, Rachwał T., Saladrigues R., **Agyarko-Fosu F**. (2023). Transition from entrepreneurship education to entrepreneurial intention: a cross-cultural effect. Czasopismo Geograficzne, 94(3): 533–552. https://doi.org/10.12657/czageo-94-20

Ankrah, D. A., Kwapong, N. A., **Manteaw, S. A**. & **Agyarko-Fosuhene, F**. (2023). Sustainable cereal production: A spatial analytical approach using the Ghana living standards survey. Heliyon 9(7): e17831 DOI: 10.1016/j.heliyon.2023.e17831

Bekoe, S., Ayoung, D. A. & **Danquah, P**. (2023), Assessing the usefulness of the e-Agriculture programme in Ghana using the Technology Acceptance Model. Ghana Journal of Agricultural Science, 58 (2), 39 - 55, https://dx.doi.org/10.4314/gjas.v58i2.3

Boateng, S. A., Ankrah, D. A. & **Manteaw, S. A**. (2023). Competence-based Education: Reflection on the context of teaching agriculture in Ghana's pre-tertiary schools. Cogent Education 10: 1, 2207793 DOI:10.1080/2331186X.2023.2207793

Dziwornu, M. G., & Coletto, D. (2023). A 'Better Life for All in Bricks and Mortar': The spatial rationalities of container urbanism in Accra. Journal of Asian and African Studies, 00219096231197752.

Gookyi, D. N. A., Lee, E., Kim, K., Jang, S. J. & Lee, S. S. (2023) Deep Learning Accelerators' Configuration Space Exploration Effect on Performance and Resource Utilization: A Gemmini Case Study, Sensors, https://www.mdpi.com/1424-8220/23/5/2380

Manteaw, S. A., Folitse, B. Y., Mahama, S. & Wahaga, E. (2023). Sources of agricultural extension information and farmers' willingness to pay for the information: Evidence from small-scale pineapple farmers in south-eastern Ghana." Africa Journal of Science, Technology, Innovation and Development, 2022. http://doi.prg/1-.10.80/20421338.2022/214 9041

Manteaw, S. A., Folitse, B. Y., Swanzy, F. K., Mahama, S. & **Adjeley, T. A.** (2023). The dynamics of mobile phone usage among small-scale oil palm processors: Evidence from the Eastern Region, Ghana, Cogent Social Sciences, 9:1, DOI: 10.1080/23311886.2023.2222570

Moller-Jensen, L., **Allotey, A. N. M., Kofie, R. Y.** & Yiran, G. A. B. (2023) How does flooding influence intra-urban mobility? The case of Accra. Sustainability, 15, 14997. https://doi.org/10.3390/su152014997

Onyeneke, R. U., Ankrah, D. A., Atta-Ankomah, R., **Agyarko, F. F.**, Onyeneke, C. J., & Nejad, J. G. (2023). Information and communication technologies and agricultural production: New evidence from Africa. Applied Sciences, 13(6), 3918.

Onyeneke, R. U., **Agyarko, F. F.**, Onyeneke, C. J., Osuji, E. E., Ibeneme, P. A., & Esfahani, I. J. (2023). How Does Climate Change Affect Tomato and Okra Production? Evidence from Nigeria. Plants, 12(19), 3477.

Zainudeen, N. M., Mohammed, L., Nyamful, A., Adotey, D. K., & Osae, S. K. (2023). A comparative review of the mineralogical and chemical composition of African major bauxite deposits. CelPress, Heliyon 9(8) ScienceDirect https://doi.org/10.1016/j.heliyon.2023.e19070

Books

Manteaw, S. A. (2023). Communication for Agricultural Extension and Innovation: A Theoretical and Applied Perspective. CSIR-INSTI Press.

Wilson, M., Keelson, Klogo,G.S (September, 2023). STEM Curriculum for Secondary School Education (SHS 1 - 3). National Council for Curriculum and Assessment of Ministry of Education.

Book Chapters

Danquah, P. (2023). Information security theories. In A Contextual Review of Information Security and Cybercrime. P. Danquah, Kani, J. A, Lartey, J. D. & Oppong, D. B., (pp. 40-47). AJPO Journals and book publishers

Danquah, P. (2023). Cybercrime related theories. In Contextual Review of Information Security and Cybercrime. P. A. Danquah, & D. B. Oppong, A (pp. 49-57). AJPO Journals and book publishers

Danquah, P. (2023). Vulnerability assessment and penetration tests. In A Contextual Review of Information Security and Cybercrime. P. Danquah, Kani, J. A, Lartey, J. D. & Oppong, D. B, (pp. 99-114). AJPO Journals and book publishers

Policy Briefs

Mponela, P., **Dziwornu, M. G., Agyarko-Fosu, F.**, Inusah, S., **Odonkor, E. N.**, **Sackey, T. A., Mamah, S. A.**, Akpatsu, I. B. (2023) Climate-smart agriculture implementation evidence in Ghana: Supporting scaling strategies for enhanced resilience in Ghana. AICCRA Ghana Cluster Reports 2023. 8 p.

Mponela, P., **Dziwronu, M. G.**, Inusah, S., **Agyarko, F. F., Odonkor, E. N., Sackey, T. A.**, **Mamah, S. A**. & Akpatsu, I. B. (2023). Towards optimised climate-smart agriculture resource investment decisions: Mapping program impact areas, policy support and mitigation feasibility.

Jizorkuwie, A. B., **Wilson, M., Danquah, P.**, **Kwao, R.**, Nurudeen, A., Dalaa, M. A., Masoud, J., Kizito, F., & Mponela, P. (2023) Evaluation of Ghana EiA-hub and mobile app digital advisories by the Research Extension Farmer Linkage Committees (RELCs). Excellence in Agronomy for Sustainable Intensification and Climate Change Adaptation. 14 p.

Conference Papers

Gookyi, D. A. N., Wilson, M., Ahiadormey, R. K., Asiedu, D. K. P., **Danquah, P.** & Gyaang, R. (2023), "The Efficiency of Convolution on Gemmini Deep Learning Hardware Accelerator," 2023 IEEE AFRICON, Nairobi, Kenya, 2023, pp. 1-5, doi: 10.1109/AFRICON55910.2023.10293709.

Gyaang, R., Abddul-Raman, A., **Gookyi, D. N. A.**, Jang, S. J. & Lee, S. S. (2023, June 25-28). Deep Neural Network Dataset Collection for Optimal Positioning of a Capacitive Compensated Schiffman Phase Shifter. International Technical Conference on

Circuits/Systems, Computers, and Communication, Jeju, Korea, https://www.itc-cscc2023.org/2023/

Stanek L., & **Dziwornu, M. G.** "Temporalities of Postcolonial and Postsocialist Infrastructure: Imaginations of Industrial Development in Asutsuare, Ghana." AAG Annual Meeting, 23-27th March 2023, Denver, USA.

Wilson, M., Nunoo-Mensah, H., & Boateng, K. O. (2023). A Review of Computational Load-Balancing for Mobile Edge Computing. In: Arai, K. (eds) Intelligent Computing. SAI 2023. Lecture Notes in Networks and Systems, vol 711. Springer, Cham. https://doi.org/10.1007/978-3-031-37717-4_7

Wulnye, F. A., Arthur, E. A. E., **Gookyi, D. A. N.**, Asiedu, D. K. P., **Wilson, M.**, & Agyemang, J. O. (2024) TinyML Implementation on Microcontrollers: The Case of Maize Leaf Disease Identification. Conference on Information Communications Technology and Society, ICTAS 2024, Durban, South Africa (http://www.ictas.org/ictas2024.html)

Technical Reports

Allotey, A. N. M., Annor, J. & Kofie, R. (May, 2023) Land use/cover change and Population Dynamics in a biosphere reserve: The case of Lake Bosomtwe Basin in Ashanti Region, Ghana.

Jizorkuwie, A.B.; **Wilson, M.; Danquah, P**.; **Kwao, R.**; Nurudeen, A.; Dalaa, M.A.; Masoud, J.; Kizito, F.; & Mponela, P. (2023) "Evaluation of Ghana EiA-hub and mobile app digital advisories by the Research Extension Farmer Linkage Committees (RELCs)". Excellence in Agronomy for Sustainable Intensification and Climate Change Adaptation. 14 p. (https://cgspace.cgiar.org/handle/10568/132834)

Kofie, R., Allotey, N. M. A., Annor, J., Lettu, C., Azuma, V., & Nortsu, O. (May, 2023) A Geospatial Approach to the study of Flood Risk Hotspots, Transport Networks and Emergency Response Services in four Peripheral Areas of Accra

Mponela, P., **Dziwornu, M. G.**, Inusah, S., **Agyarko-Fosu, F.**, **Odonkor, E. N.**, **Sackey, T. A.**, **Mamah, S. A**., & Akpatsu, I. B. (2023) Towards optimised climate-smart

agriculture resource investment decisions: Mapping program impact areas, policy support and mitigation feasibility. AICCRA Ghana Cluster Reports 2023. 93 p.

Mponela, P., **Dziwornu, M. G.**, **Agyarko, F. F.**, Inusah, S., **Odonkor, E. N., Sackey, T. A., Mamah, S. A.** & Akpatsu, I. B. (2023). Climate-smart agriculture implementation evidence in Ghana: Supporting scaling strategies for enhanced resilience in Ghana.

Wilson, M. (2023) Ghana GAIP Use Case: Progress in the development and deployment of EiA Digital Advisory Platform. Technical implementation report. 19 p. (https://hdl.handle.net/10568/134941)

Wilson, M. Tepa-Yotto G, Dalaa M, Martey F, Yeboah S, **Awotwi J, & Danquah P.** 2023. Ag-Data Hub: Cultivating Innovation, Harvesting Insights, Growing a Sustainable Future. Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA).

APPENDIX B: External Training

Workshops/ Conferences/ Seminars & Others attended in 2023

Abdulai S. M. participated in;

- The International Day for Women and Girls in Science celebration forum on 10th February 2023 at the University of Ghana.
- The Women in Innovation and Research Conclave (WIRC 2023) on 30th June 2023 at Fiesta Royale Hotel, Accra.

Adikah-Ababio A. participated in a training workshop on Fixed Assets Register and Data Collection to Controller and Accountant General's Department on 17th January 2023 at the CSIR Head Office.

Adjah J. participated in a training programme on Patent Registration and Intellectual Property, on 19th December 2023 at CSIR Head Office.

Agyarko, F. F. participated in the Science, Technology and Innovation Management Information System Inception Meeting on 6th April 2023 at Holiday Inn Hotel, Accra.

Ahiadormey R. K. participated in the 2023 IEEE AFRICON online conference on 21st September 2023.

Allotey A. N. M. facilitated

- The CLIMACCESS Dissemination and Outreach Workshop on 15th November 2023 at African Regent Hotel, Accra.
- participated in;
- A FETE Project inception workshop from 21st to 24th November 2023 at the Sokoine University of Agriculture, Tanzania.
- A research collaboration workshop on 30th September and 11th October 2023 in Copenhagen, Denmark.

- A 2-day food security workshop themed – Enhancing Food Security: The Role of the Ghanaian Scientist, from 17th to 19th May 2023 at the Pentecost Convention Centre, Gomoa Fetteh.

Ampofo-Addo A. S.

participated in;

- The Commissioning of the National Children's and Mobile Library on 15th February at the forecourt of the library.
- A webinar on Introduction to ORCID & ORCID Membership on 20th November 2023.
- A webinar on AGROVOC: Making research more visible across languages on 5th December 2023.

Served as;

- A guest facilitator for the Research4Life Massive Open Online Course from 16th May to 16th June 2023.

Annor J. participated in the CLIMACCESS Dissemination Workshop on 15th November 2023 at African Regent Hotel, Accra.

Ankrah S. participated in;

- A training on Fixed Assets Register and Data Collection to Controller and Accountant General's Department on 17th January 2023 at the CSIR Head Office.
- A workshop on the Review of Procurement Procedures on 31st August 2023 at the CSIR Head Office, Accra.
- A training on the Ghana Electronic Procurement System (GHANEPS) on 14th September 2023 at the CSIR-Head Office.

Asante S. K. participated in;

- A training workshop on Fixed Assets Register and Data Collection to Controller and Accountant General's Department on 17th January 2023 at the CSIR Head Office

- The 2023 Second Quarter Accountants' Meeting from 20th to 21st July 2023 at CSIR-FORIG, Kumasi.
- A 3-day online training on Taxation of Individuals, Businesses and Filing of Returns from 25th to 27th July 2023.
- An Internal Support Staff training on the New GoG Fixed Assets Register (FAR) on 22nd August 2023 at the Institute of Local Government Studies.
- The EIA Data Validation workshop from 31st August to 1st September 2023 at the Anita Hotel, Kumasi
- An Engagement Meeting on the Production of Quarterly and Annual Financial Reports and Fixed Assets Register from 7th to 8th November 2023 at CSIR Head Office.
- The CLIMACCESS Dissemination and Outreach Workshop on 15th November 2023 at African Regent Hotel, Accra.
- The Third Quarter Accountants Meeting from 28th to 29th November 2023 at CSIR-PGRRI.

Awotwi J. P. participated in;

- The NITA Stakeholder meeting from 5th to 7th July 2023, at Kofi Annan ICT Centre, Accra.
- The Meeting on Cereal-Legume Agronomy Scaling and Acceleration Platform (GH-CerLeg-GAIP) of the Excellence in Agronomy 2030 Initiative from 15th to 17th August 2023 at Mariam Hotel, Tamale.
- The EIA Data Validation workshop from 31st August to 1st September 2023 at the Anita Hotel, Kumasi
- An EiA -IFDC Workshop on Fertilizer Recommendations on 25th September 2023 at Airport View Hotel, Accra.
- The Multi-Stakeholder Conference on Pesticides on 26th September 2023, at Holiday Inn, Accra.

- The Multi-stakeholder Dialogue on National Agricultural Data Infrastructure in Ghana from 7th to 8th December 2023 at the Commonwealth Secretariat.

Azuma V. Y. participated in the CLIMACCESS Dissemination and Outreach Workshop on 15th November 2023 at African Regent Hotel, Accra.

Danquah P. A participated in;

- The Open group Architecture Forum (TOGAF) course organised by Certified Ghana from February 27th to March 3rd 2023.
- The Food Security Resilience Programme (FSRP) Environmental & Social Risk Management Training from 27th to 29th September 2023 at Capital View Hotel, Koforidua.
- The Multi-stakeholder Dialogue on National Agricultural Data Infrastructure in Ghana from 7th to 8th December 2023 at the Commonwealth Secretariat.
- The 2023 IEEE AFRICON online conference on 21st September 2023.

Decardi-Nelson A. participated in;

- A 2-day food security workshop themed – Enhancing Food Security: The Role of the Ghanaian Scientist, from 17th to 19th May 2023 at the Pentecost Convention Centre, Gomoa Fetteh.
- The Women in Innovation and Research Conclave (WIRC 2023) on 30th June 2023 at Fiesta Royale Hotel, Accra.
- A workshop on The state of genetically modified crops, the case of Ghana on 18th August 2023 at Holiday Inn Airport Hotel.
- The National Gender Training for Food Systems Resilience Programme (FSRP) Stakeholders from 22nd to 25th August 2023 at Sunset Hotel, Koforidua.

Dusi M. served as rapporteur for the CLIMACCESS Dissemination and Outreach Workshop on 15th November 2023 at African Regent Hotel, Accra.

Dziwornu M. G. participated in;

- The Meeting on Cereal-Legume Agronomy Scaling and Acceleration Platform (GH-CerLeg-GAIP) of the Excellence in Agronomy 2030 Initiative from 15th to 17th August 2023 at Marian Hotel, Tamale.

- The EIA Data Validation workshop from 31st August to 1st September 2023 at the Anita Hotel, Kumasi

Kofie R. Y. facilitated the CLIMACCESS Dissemination and Outreach Workshop on 15th November 2023 at African Regent Hotel, Accra.

Kumiwa D. participated in a training workshop on Fixed Assets Register and Data Collection to Controller and Accountant General's Department on 17th January 2023 at the CSIR Head Office

Lamptey J. N. attended the Bloomberg Road Safety Workshop on 20th October 2023 at Ange Hill Hotel, East Legon

Lawal R. participated in:

- An Internal Support Staff training on the New GoG Fixed Assets Register on 22nd August 2023 at the Institute of Local Government Studies.

- An Engagement Meeting on the Production of Quarterly and Annual Financial Reports and Fixed Assets Register from 7th to 8th November 2023 at CSIR Head Office.

Manteaw S. A.

- Served as a resource person for AUDA-NEPAD Centre of Excellence in STI Writing Workshop to Develop a Genome Editing National Communication Strategy and Action Plan for the Government of Malawi from 19th to 23rd June 2023 in Lilongwe, Malawi

Coordinated;

- A 5-day workshop to Validate Ghana's Genome Editing Communication and Advocacy Strategy from 29th May to 2nd June 2023 at Labadi Beach Hotel, Accra

- A 2-day workshop on Strengthening Institutionalised Capacity in Genome Editing and Biotechnology R & D through Strategic Alliances with Universities and Colleges, from 20th to 21st November 2023 at Oak Plaza Hotel, Accra

- A workshop on Advancing Science, Technology and Innovation in Africa, Genome Editing Landscape Analysis in Selected Africa Countries from 22nd to 24th November 2023 at Oak Plaza Hotel, Accra

Participated in;

- The Convening on Agronomy, R&D Priorities and Climate Change Adaptation from 1st to 2nd February 2023 in Nairobi, Kenya.

- A study tour on Advancing Science, Technology and Innovation in Africa: from 13th to 17th February 2023 in Addis Ababa, Ethiopia

- An STI workshop on AUDA-NEPAD Centre of Excellence to Draft and Commission Knowledge Products to Aid Effective Communication and Advocacy of Genome Editing for Enhanced Uptake in Africa Countries from 8th to 12th May 2023 in Harare, Zimbabwe.

- A 2-day food security workshop themed – Enhancing Food Security: The Role of the Ghanaian Scientist, from 17th to 19th May 2023 at the Pentecost Convention Centre, Gomoa Fetteh.

- A Continental Expert Group Meeting on Advancing STI in Africa Initiative to Develop Genome Editing Training Materials and Curricula from 27th June to 1st July 2023 in Maputo, Mozambique

- A Continental Expert Group Meeting to Review and Finalise the Genome Editing Communication Training Programme and Modules Workshop from 14th to 18th August 2023 in Lilongwe, Malawi.

- The EIA Data Validation workshop from 31st August to 1st September 2023 at the Anita Hotel, Kumasi

- The Lead Agencies Review and Working Session on National Communication and Advocacy Strategies and Action Plans from 10th to 12th October 2023 in Magaliesburg, Johannesburg, South Africa

- A Strategic Meeting with Local, Regional Actors, International Partners, Key Constituencies and the Private Sector from 16th to 18th October 2023 in Mombasa, Kenya

- A Stakeholder Validation of Genome Editing Communication and Advocacy Training Materials and Curricula from 15th to 17th November 2023 in Addis Ababa, Ethiopia

Nortsu O. participated in;

- An AuthorAid online capacity training on Foundational skills for Social Science and Health Research from 16th May to 3rd July 2023.

- An AuthorAid online capacity training on Mastering Grant Proposal Writing from 24th October to 27th November 2023.

- The CLIMACCESS Dissemination and Outreach Workshop on 15th November 2023 at African Regent Hotel, Accra.

Odonkor E. participated in;

- A Ghana Industry-University-Research Institutions Collaborative (GIURIC) Discovery Roundtable discussion on 14th April 2023 at Royal Fiesta Hotel, Accra.

- An online 3-day training on Policy Brief preparation from 23rd to 25th May 2023.

- A training workshop on National Innovation Systems and Innovation Management organised by the African Union 20th to 25th November 2023 at CSIR-STEPRI.

- A 2-day food security workshop themed – Enhancing Food Security: The Role of the Ghanaian Scientist, from 17th to 19th May 2023 at the Pentecost Convention Centre, Gomoa Fetteh.

Ohene-Affih B. participated in the EIA Data Validation workshop from 31st August to 1st September 2023 at Anita Hotel, Kumasi

Sackey T. A. participated in;

- The International Day for Women and Girls in Science celebration forum on 10th February 2023 at the University of Ghana.

- The Women in Innovation and Research Conclave (WIRC 2023) on 30th June 2023 at Fiesta Royale Hotel, Accra.
- The Meeting on Cereal-Legume Agronomy Scaling and Acceleration Platform (GH-CerLeg-GAIP) of the Excellence in Agronomy 2030 Initiative from 15th to 17th August 2023 at Mariam Hotel, Tamale.
- The EIA Data Validation workshop from 31st August to 1st September 2023 at the Anita Hotel, Kumasi
- A training programme on Patent Registration and Intellectual Property, on 19th December 2023 at CSIR Head Office.

Sarpong, S. G. participated in a workshop on the Review of Procurement Procedures on 31st August 2023 at the CSIR Head Office, Accra.

Wilson M. participated in;

- A Stakeholders' Engagement Meeting for Developing Climatic Digital Advisory Tools in Ghana from 24th to 25th February 2023 at Tang Palace Hotel
- The AICCRA Ghana Cluster Workshop from 24th to 26th May 2023 at Volta Hotel, Akosombo.
- The Development of year-one Teacher Manuals for the Secondary Education Curriculum from 5th to 9th June and 19th to 23rd June 2023 at Volta Serene Hotel, Ho.
- The EIA Data Validation workshop from 31st August to 1st September 2023 at the Anita Hotel, Kumasi
- The 2023 IEEE AFRICON online conference on 21st September 2023.

Zainudeen, N. M. participated in;

- The Forum of Ghana's Nuclear Power Programme on 30th May 2023 at the Accra International Conference Centre.

- The Nuclear science & Technology for Socio-economic development in Africa: Atoms for Peace and Development Forum on 3rd November 2023 at the Ghana Atomic Energy Commission (GAEC).

- The Pan-African Nuclear Training Programme organised by the US-DOE. The year-long course commenced on 2nd February 2023 and would end on 8th February 2024.

APPENDIX C: Staff List

Staff list as at 31st December 2023

Table C1

Senior Members

Nº	NAME	PRESENT DESIGNATION	QUALIFICATION
1	Dr. Seth Awuku Manteaw	Principal Scientific Information Officer/Director	PhD (Agricultural Extension); MSc (Agronomy); PG Dip. (Communication Studies); MA (Communication Studies)
2	Dr. Paul Asante Danquah	Principal Research Scientist/ Acting Deputy Director	PhD (Info. Technology); MSc. (Info. Security); BSc. (Hons) Computing
3	Dr. Richard Kofie*	Principal Research Scientist/ Former Deputy Director	PhD (Geography); MPhil(Geography); BA (Hons) Cert (Remote Sensing)
4	Dr. Albert N. M. Allotey	Snr. Research Scientist/ Head of Geospatial & Information Science	PhD (Geography & Resource Development); MPhil (Geography & Resource Development) BA (Hons) Geography & Resource Development
5	Mrs. Dorothy Awanyo	Snr. Administrative Officer/ Head of Administration	MBA (Human Resource Mgt); BA (Public Admin.); Dip. (Librarianship)
6	Mr. Stephen K. Asante Jr.	Snr. Accountant/ Head of Accounts	MBA (Accounting & Finance) BSc (Economics & Bus. Adm.) CA Ghana
7	Dr. Agnes Decardi-Nelson	Research Scientist/ Head of Printing & Publishing	PhD (African Art & Culture); BFA (Graphic Design)
8	Dr. Roger K. Ahiadormey	Research Scientist/ Head of Communications	PhD (Electronic Engineering) MA (Electronic Engineering) BSc (Electrical/Electronic Engineering)

9	Ing. Michael Wilson	Chief Technologist/ Head of Electronics	MPhil. (Computer Engineering); PostGrad. (Wireless &Mobile Computing); CDAC; BSc. Computer Eng.;
10	Ms. Anita Adusah	Snr. Administrative Officer	MBA (Human Resource Mgt); BSc (Mgt with Computing (HR)); HRM Certificate Level 3
11	Ms. Naa Aku Mingle	Snr. Librarian	MPhil (Information Studies) BA (Psychology & Linguistics)
12	Mr. Atta S. Ampofo-Addo	Librarian	MSc (Management Information Systems)CIM-UK (Level 1); BA (Info. Studies & Sociology)
13	Mr. Bryan N. L. Laryea	Research Scientist	MBA (Management Information Systems) BA (Information Studies & Geography)
14	Dr. Michael G. Dziwornu	Research Scientist	PhD (Urban Studies) MA (Geography) BA (Geography & Resource Development & Information Studies)
15	Dr. Dennis N. A. Gookyi	Research Scientist	PhD (Info. & Comm. Engineering) MA (Info. & Comm. Engineering) BSc (Computer Engineering)
16	Dr. Ezekiel Narh Odonkor	Research Scientist	PhD MPhil (Agricultural Administration) BSc (Agric Crop Science)
17	Mr. Yaw Twum-Barimah	Chief Technologist	MSc. (Telecom); BSc. Elec. & Computer Engineering
18	Ing. Victor D. Gordon	Chief Technologist	MSc. (Telecommunications & Internet Technologies) BSc. (Computer Engineering)
19	Mr. Mohammed Nafiu Zainudeen	Chief Technologist	MSc. (Chemical Eng.); BSc. (Hons) Chemical Eng.
20	Mr. Akilakpa Sawyerr	Chief Technologist	MPhil (Radiation Protection); BSc. (Physics)

21	Mr. Christian K. Lettu	Chief Technologist	MPhil (Dev. Geography); BA (Hons) Geography & Resource Development
22	Mr. John Annor	Chief Technologist	MPhil (GIS & Remote Sensing); B.A. (Geography)
23	Ing. Frank Lemdi Prikutse	Principal Technologist	MSc. (Telecom Engineering); B.Eng. (Telecom Engineering)
24	Mr. John Adjah	Principal Technologist	MA (Communication Design); BA (Publishing Studies)
25	Ms. Tracy Adjeley Sackey	Principal Technologist/ Scientific Secretary	MPhil (Radiation Protection); BSc. (Physics & Computer Science)
26	Mr. Buertey Essegbey	Principal Technologist	MA (Business Administration) BSc (Management Studies)
27	Mr. Kenneth Asiamah	Principal Technologist	MSc (Information & Communication Technology) BSc (Information & Technology Management
28	Mr. Fred Fosu Agyarko	Principal Technologist	MPhil (Statistics) BSc (Actuarial Science)
29	Mr. Oliver Nortsu	Principal Technologist	MPhil (Geography & Regional Planning) BED (Mathematics)
30	Mr. Michael A.Alhassan	Principal Technologist	MSc (Computer Engineering, Computer Systems & Networks) BSc (Computer Engineering)
31	Mrs. Akua Boateng-Agyenim	Marketing Officer	MBA (Marketing) BA (Publishing Studies)
32	Ms. Risikatu Lawal	Accountant	MBA BSc. (Accounting); DBS (Accounting); CIPS Cert. (Purch. & Supply)

On Contract

Table C2

Senior Staff

Nº	NAME	PRESENT DESIGNATION	QUALIFICATION
1	Mr. Edwin Adotevi	Snr. Technologist	BA (Comm. Studies)
2	Mrs. Janet Otoo-Abedi	Chief Accounting Assistant	Diploma (Public Finance and Accountancy)
3	Ms. Cordellia A. Busumtwi	Chief Administrative Assistant	Cert. (Private Secretary)
4	Mr. William K. Akpakli	Chief Security Officer	BA (Social Work & Psychology)
5	Mrs. Margaret I. Koranteng	Chief Library Assistant	Diploma (Librarianship)
6	Mrs. Sarah G. Sarpong	Chief Accounting Assistant	Dip. (Public Finance and Accountancy)
7	Ms. Angela Adikah-Ababio	Principal Auditing Assistant	BSc (Business Adm.-Accounting) ACCA Part II
8	Mr. Alex K. I. Ocansey	Principal Assistant Printer	Cert. (ITS) Snr. Sup/ Mgt; N.V.T.I. Grade I Cert.
9	Mr. Eric Sam	Principal Technical Officer	BFA (Animation) HND (Graphic Designing)
10	Mr. Samuel Ankrah	Principal Accounting Assistant	Bachelor of Commerce; HND (Accountancy);
11	Ms. Doris Kumiwa	Snr. Administrative Assistant	Dip (BCom Management) DBS (Secretariaship); Nat. Banking Coll. (Cert Cashier & Frontline Exec)
12	Mr. Benjamin Ohene-Affih	Technical Officer	B.Eng. (Computer Science)
13	Mr. John Paapa Awotwi	Technical Officer	BSc. (Information Technology)
14	Ms. Samiratu M. Abdulai	Technical Officer	BA (Communication Design)
15	Mr. Yaw Owusu-Ayirebi	Technical Officer	BA (Graphic Design)

16	Mr. Eric K. Acquaye	Technical Officer	Advanced Certificate in Microsoft Certified Systems Eng. (GIMPA)
17	Mr. Irvyne Jojo Blisset	Technical Officer	BSc (Information Technology)
18	Mr. Emmanuel A. Kwofie	Technical Officer	BSc (Engineering Physics)
19	Mr. Edward Aggrey-Fynn	Technical Officer	BA (Computer Science & Management)
20	Mr. Godwin Aborgeh	Technical Officer	BSc (Industrial Chemistry)
21	Ms. Victoria Y. Azuma	Technical Officer	BA (Sociology & Geography)
22	Mr. Cyril N. Tawiah	Technical Officer	BSc (Information Technology)
23	Mr. Moses Dusi	Library Assistant	BA (Information Studies & Computer Science)
24	Ms. Esther O. Nyarko	Library Assistant	BA (Adult Education & Information Studies) Dip (Youth Development Work)
25	Ms. Anne Hawa Breh	Library Assistant	BA (Information Studies & Sociology)
26	Mr. Patrick Folitse	Marketing Assistant	BSc (Business Administration (Marketing))
27	Ms. Yvonne D. Azuma	Administrative Assistant	Dip (Public Administration) SSSCE
28	Ms. Winifred Taylor	Accounting Assistant	BSc Accounting
29	Mr. Cephas Awusie	Security Officer	Security Training Module I; G.C.E. 'O' Level
30	Mr. Abdul Rahaman Iddrisu	Security Officer	Security Training Module I; M.S.L.C.
31	Mr. Fuseini Inusah	Security Officer	SSSCE
32	Mr. Precious D. Attih	Security Officer	BSc (Agricultural Engineering)
33	Mr. Timothy Kwamena	Assistant Transport Officer	Cert. (Trans Mgt); Intercity STC Coaches Ltd.; MSLC

Table C3

Junior Staff

Nº	NAME	PRESENT DESIGNATION	QUALIFICATION
1	Mrs. Salamatu Abdul Mumuni	Senior Clerk	NACVET Cert. (Stenographer)
2	Ms. Lucy Akyempon	Senior Clerk	"O" level, DBS
3	Ms. Cynthia Osei Bonsu	Senior Technical Assistant	HND (Estate Management)
4	Ms. Stephanie N. Nyinaku	Senior Accounts Clerk	HND (Accounting)
5	Mr. Bancie Habila Hussein	Junior Library Assistant	SSSCE
6	Mr. Joseph Lamptey	Traffic Supervisor	Intercity STC (Def. Driving Course); BECE
7	Mr. Seth Asare	Artisan	Special Junior Tech. Super. Mgt Course, ITS- Accra; MSLC
8	Mr. Mathew Narteh Amoatey	Driver Inspector	Course on Road Safety Mgt. (ATS) City & Guild (Mech. Eng. Craft Practice); BECE; Drive. Lic "C"
9	Mr. Bright K. Yankey	Driver Mechanic Grade II	NVTI GD II
10	Mr. Razak Ayidana Akambase	Supervisor Grade I	B.E.C.E.
11	Mr. Kojo Asanaab	Supervisor Grade I	B.E.C.E.
12	Mr. Isaac G. Amponsah	Supervisor Grade I	NVTI GD II
13	Mr. Robert Achandi	Supervisor Grade I	M.S.L.C.
14	Mr. Francis Ayarik	Supervisor Grade I	Nil
15	Mr. Abdul Wahab Usman	Supervisor Grade II	Nil