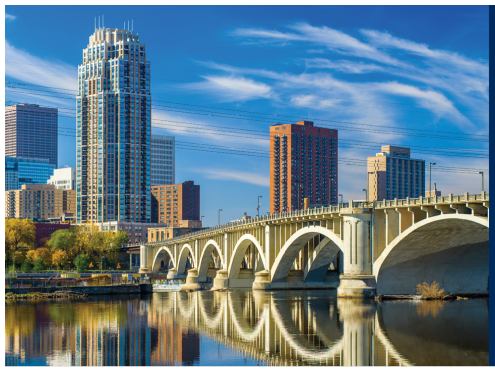

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Low-cost Data Analytics for Farmers

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Farmer Charlie – Low-cost Data Analytics for Farmers Accessible in the Field

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Abstract

Farmer Charlie is based on an affordable business model including five elements: a data analytics platform, an agri-business ecosystem application, capable of connecting with local third-party apps; weather and in field sensors; Wi-Fi Internet connectivity; and power to the field and farms via solar panels. Farmer Charlie brings information to farmers in their own fields, in an easy plug and play solution, affordable to the farmers and addressing their needs in a smart and localized way. It can be integrated with other third-party apps. Farmer Charlie is very innovative, bringing in a sustainable business model, supporting farmers in farming techniques but also caring for the environment, managing natural resources (e.g., water, pesticides, fertilizers) more effectively. Farmers in Nigeria, Sicily and the UK have shared their needs and challenges with us, so that we could serve them better. Farmer Charlie was born out of a 2018 study for the European Space Agency (ESA), about potential applications and services of large satellite constellations. The consortium included six experts in 5G, satellite communications, emergency response, digitalization, weather, and disaster risk management. This study showed the potential for a range of applications. Working on the outcome of it to investigate a cost-effective solution, we found out that weather and field information is crucial for farmers, especially smallholders and especially when they work in isolate and remote areas with scarce or no connectivity.

Keywords

Low cost, IoT, irrigation control, broadband connectivity, plug and play

Introduction

Farmer Charlie is a spin-off startup born out of a European Space Agency (ESA) study on the potential application of communication satellites in agriculture. In 2017, Farmer Charlie's parent company, AB5 Consulting won a competition promoted by ESA to conduct a feasibility study on potential advantages and applications of satellite constellations. The research performed for that study included ideas and developments on the best usage of weather stations and satellite technology in agriculture, climate change and disaster prevention, with particular attention to the issues faced by Least Developed and Sub-Saharan countries. The ESA study, therefore, triggered the idea of a cost-effective system to support small farmers in their agricultural activities, offering them connectivity and advice based on a cost-effective and flexible platform.

A need exists for bringing connectivity and information to farmers, especially those based in remote and isolated areas lacking Internet coverage. During our ESA study, we found out that less weather stations are installed on the whole area of Africa than in Switzerland, one of the smallest European countries in size. Connectivity is also a major issue: "[…] in least developed countries (LDCs), […] 17 per cent of the rural population live in areas with no mobile coverage at all, and 19 per cent of the rural population is covered by only a 2G network" (2020). The data functioned as a trigger to deepen the research into the link between information, connectivity, and technology adoption to improve the condition of farming.

Funding provided by Innovate UK and UK DFID allowed us to start researching and applying our solution in the Oyo state in Nigeria. This was followed by further contacts and studies in other states of Nigeria and in Côte d'Ivoire. During the pandemic period, the first Farmer Charlie sensors were eventually installed in the Italian region of Sicily, where tests and trials are currently ongoing.

The core components of Farmer Charlie platform are connectivity, in-field sensors, solar panels providing energy, and the application. The Farmer Charlie platform is built on the ability to deliver specific and relevant information to farmers in the field. Using satellite data, remote sensors, and our own in-field sensors, we can monitor the conditions of our partner farming operations in real-time. We are able to access weather information, measure water resources, classify vegetation, map the lay of the land, provide analytics, and so much more. We can also take our information and analytics offline when necessary.

With the ability to measure all relevant farming statistics in real time, our system can help inform decisions on resource usage and increase food production. It takes the guesswork out of farming. Farmer Charlie can also integrate with drones and Earth Observation, which helps us to improve the accuracy and scale of our visualizations. Overlapping observations from up close and far away helps our team to identify big and small trends that affect the conditions on site. The integration of drones and Earth Observation also expands our network of partnerships with other actors in the agri-tech community.

We base our offer on on-farm experimentation, which includes participation by farmers, agricultural innovative systems and user-driven research leading to collaborative solutions. Scientific research and farmer knowledge and experience are equally considered for achieving the best tailored solutions and agricultural practice.

1. Nigeria

1.1 The country

With a population of over 206 million people (World Bank, 2020), 165 million smallholder farmers (CGAP, 2017), the largest African economy (Blomberg, 2020), Nigeria aptly represents sub-Saharan Africa (684 million smallholder farmers, McKinsey, 2019). Nigeria is the world's largest producer of cassava, with 90% consumed locally (Ikuemonisan & al., 2020). Postharvest wastes range between 50% and 83% but could easily be reduced if harvest was timed with market needs (Danilola, 2019). Information is key for optimized farming and revenue from cassava.

Despite being the highest producer of cassava in the world (59M tons - 20.4% world share in 2017) and the second by consumption, Nigeria usually records a small total export value (USD 1.25M), outshone by Thailand USD1.19billion (Otekunrin-Sawicka, 2019). China, UK, USA, The Netherlands, and Canada are the leading importing countries. Nigeria's average yield rate was 8.7 t/ha in 2017, while it was 23.07 t/ha in Thailand. Factors contributing to this gap include choice of stems and fields, improper usage of fertilizer, high postharvest losses, small-scale farming without possibility to commercialize the production, cyclical markets gluts, policy inconsistencies, low level credit available, high transaction costs. Because cassava is drought resistant, it is planted in poor soil and basically grown for subsistence by smallholders (Romero, 2012). Urban markets account for 60% of total cassava demand, whereas 20% goes to rural markets, 10% to export and 10% to produce flour (Cabri, 2019). The potential to use the production more evenly and to spread it over food products, animal feed and industrial derivates is huge. To allow it to be adequately exploited, enabling farmers to understand enhanced agricultural practices and technologies, as well as acting with local cooperatives and partners to create a path into the value chain is crucial. Meeting the demand of cassava in industrial and export markets could create over 1M jobs (flour, sweeteners, animal feed, high quality gari for export and cities) in Nigeria (Otekunrin, cit.).

Nigeria is also one of the largest countries in Africa, with low level of internet connectivity, affecting the communication of relevant and tailored information such as weather and agronomic data to farmers. Internet penetration was 51% at the start of 2021 (datareportal.com, 2022).

1.2 Healthy and Sustainable Agriculture of Cassava (HASAC) in Nigeria

In 2020, Innovate UK funded a project to develop the Healthy and Sustainable Agriculture of Cassava (HASAC) in Nigeria project. The consortium we led included University College London (UCL) and a Nigerian company with links to farmers in the Oyo state. Farmers were represented by the Oyo State Cassava Growers' Association (OYSCGA), which was crucial for providing advice on cassava activities and allowing for a pre-selection of farmers interested in the project.

Oyo is the 14th Nigerian state by size, with 5.6 million inhabitants. Situated in the south-west, it has a tropical climate with wet and dry seasons, an average temperature of 21°C, average annual rainfall of 1250mm (www.oyostate.gov.ng). 73.1% of farms measure less than 5 hectares. Farmers obtain 79% of their farming advice through the OYSCGA extension agents, 37% through TV, 32% through friends, and 13% from Internet (Oyegbamy, 2018).

The first phase of the project involved twenty-one pilot plots (total 105 acres or 42.4ha), planted with cassava stems, where we planned to collect data about soil, humidity, growth.

The 18-month project, started in June 2020, encountered several challenges due to the spread of the COVID-19 pandemic with related travel and supply issues. During the second and third quarter of the project, the consortium was forced to reconsider travelling to Nigeria as initially planned. An on-field trip had to be postponed, then cancelled. Obtaining satellites, solar panels and other pieces of equipment eventually installed in Nigeria took longer than expected because of the pandemic.

Further challenges arose when the sensors used for this test case had to be tested to satisfy local regulations on non-commercial equipment.

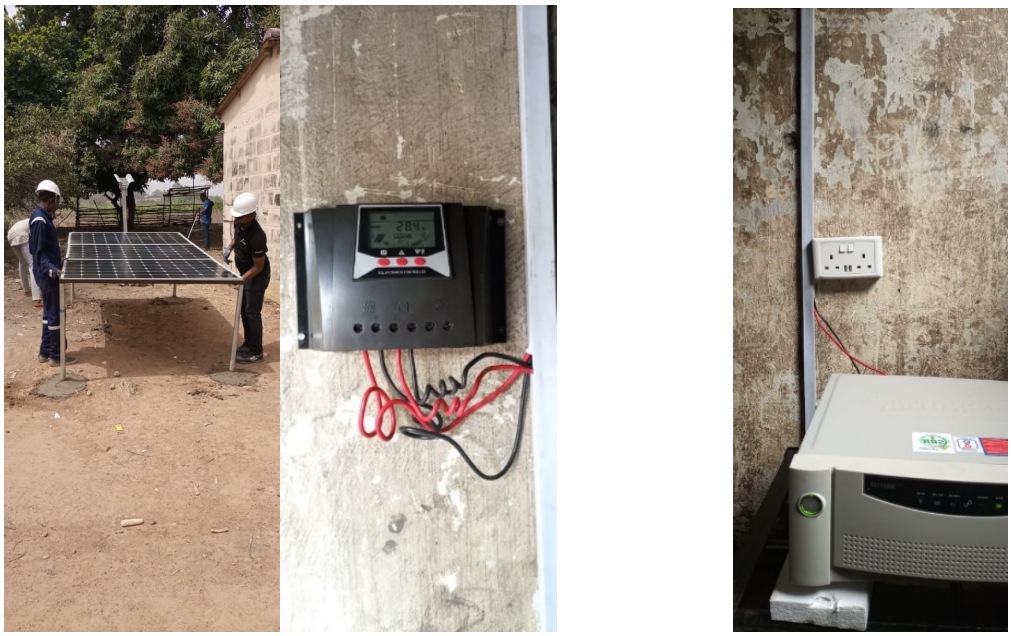

Figure 1 - Installation in Oyo State, Nigeria.

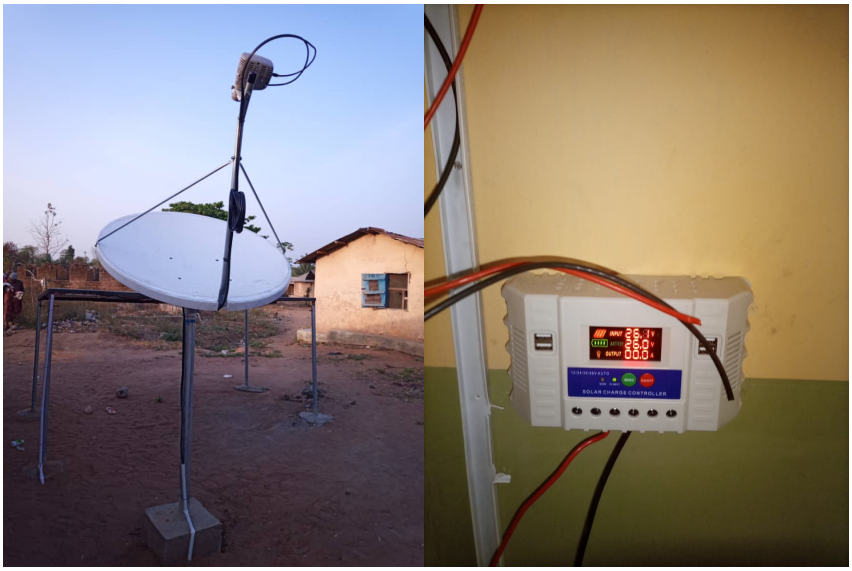

Figure 2 - Installation, Oyo State, Nigeria.

1.3 Learning outcome

The HASAC project was an invaluable source of learning and enjoyment. Even though Covid-19, remote collaboration and working, and the obstacles faced, we widened our knowledge on methodologies, challenges, risks, and practical elements encountered in developing such a project. The Innovate UK funding allowed Farmer Charlie to bring our TRL further from 3-4 to 5-6. The company was able to improve our system integration and refine the system requirements. Following the various steps of the planting and growth cycle and considering the local environment, climate change, practical and social features in Oyo, one of Nigeria states, was enriching and exciting for the whole Farmer Charlie team. Missing the opportunity to visit the place in person remains a huge regret, as we would have liked to meet with farmers in person and establish a closer relationship than what we could obtain by an interesting yet limited video call in April. Even so, we were immensely grateful to the farmers for their enthusiasm and their arduous work.

Research on crops, agronomy, and conditions of small farmers in Europe and in the LDCs increased and strengthened our awareness of the needs and pains of farming communities. Matching our spin-off objectives with sustainability purposes and the UN Sustainable Development Goals also led Farmer Charlie to embed sustainability in our culture and encourage farmers towards sustainable farming.

Understanding that one of the crucial issues to bridge the digital technology gap is the adoption of such technology by farmers, new self-funded research started and is continuously ongoing on the best practice to facilitate adoption, and on the interaction between technology and farmers.

The project also increased our interest in R&D and we are proud to assign over 25% of our profits to these activities. Overall, the Healthy and Sustainable Agriculture of Cassava in Nigeria has been a valuable and exciting experience, providing us with information, ideas, and know-how.

The extensive network of contacts created in Nigeria improved our potential for partnerships and increased our expectations for establishing a valuable market for our solution.

2. Côte d'Ivoire

2.1 Facilitating the Adoption of Farmer Charlie's Technology by Smallholder Farmers in Emerging Countries. A Feasibility Study

This step looks at mechanized commercial farming and on-site processing to add value to farms' produce in Nigeria. Working with the Enugu State Government through the Ministry of Agriculture, we are collaborating with a community of 10,000 farmers. In January 2021, we ran a survey amongst one hundred cassava farmers, and 94% wanted Farmer Charlie to access information on soil, input, weather, government programmes, market, mechanization, tools, financing.

This survey, knowledge coming from our previous experience, and relentless research confirmed that a crucial challenge for improving farming, especially in developing countries, is linked to technology adoption by local farmers. The offer of recent technology and tools to communities and users who could not possibly be familiar with them must be based based on understanding their needs, creating trust and communication with them.

While we were establishing contacts and preparing installations for Farmer Charlie in Sicily, Italy, we also devoted our energies to deepen our knowledge of the above topic. We developed a feasibility study on the challenges of technology adoption and information transfer to farmers. We researched and considered several countries in sub-Saharan Africa but also included data and insights on European countries, comparing different situations and the potential application of Farmer Charlie to diverse communities, farming typologies and needs.

2.2 Visit to Côte d'Ivoire

In spring 2022, Farmer Charlie team met with an array of official entities and farming companies, including small farmers located in remote villages in the Republic of Côte d'Ivoire. Several public institutions, companies, and other organizations were visited. This helped to assess the condition of agriculture and technology and the challenges currently present in Côte d'Ivoire. Some examples of the stakeholders included are the National Centre for Agronomy (CNRA), the Ministry of Agriculture, the Ministry of the Environment, NGOs, local businesses. Visits to local villages included Zala and Yoredoula in the Vavoua region, where meetings with local women associations took place.

The project and the visit helped Farmer Charlie to learn about the conditions and needs of farmers in Côte d'Ivoire, and at the same time to compare and explore the situation of other sub-Saharan countries like Nigeria, Kenya, and Tanzania. Thanks to the outcome of this project, we realized that there are certainly opportunities to move forward and to adapt our solution to respond to farmers' needs and pains in Côte d'Ivoire. This will foster new developments for Farmer Charlie, too. In addition to defining the markets for Farmer Charlie (plantations & community farming), the visit provided serious leads, which we are working to turn into contracts.

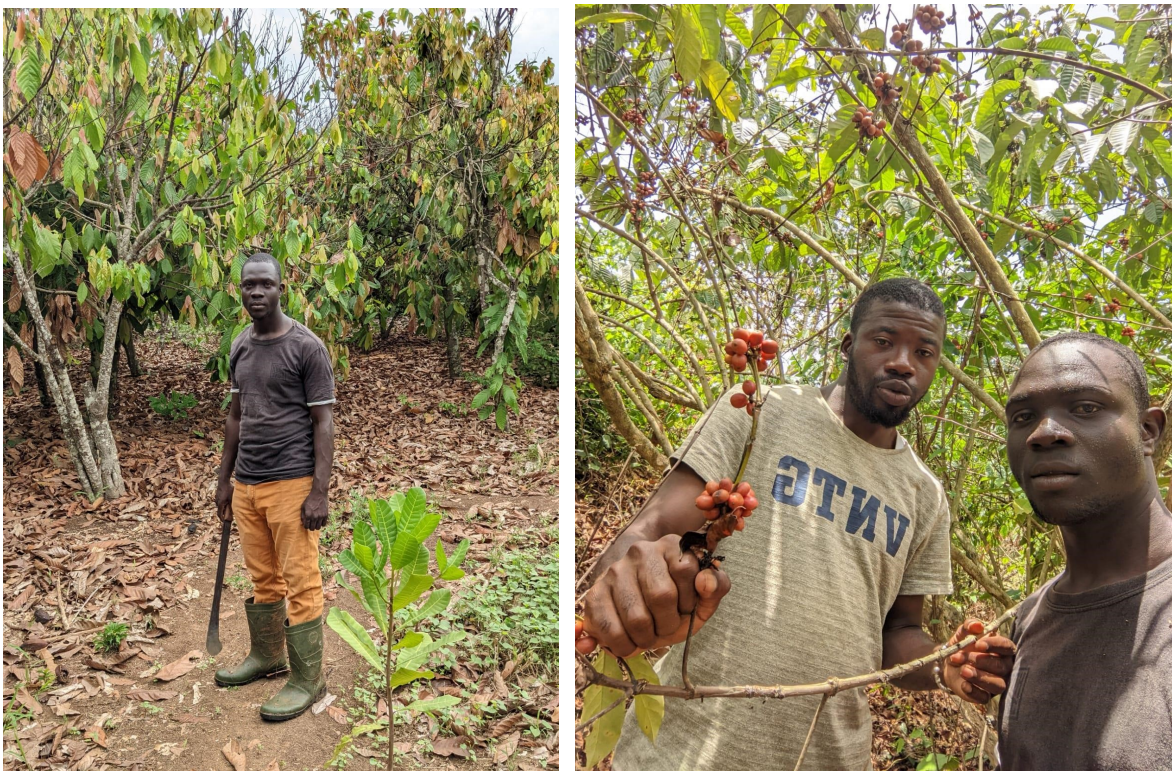

Figure 3. A member of Farmer Charlie team with a local farmer at Vavoua, in the Haut Sassandra region, Côte d'Ivoire.

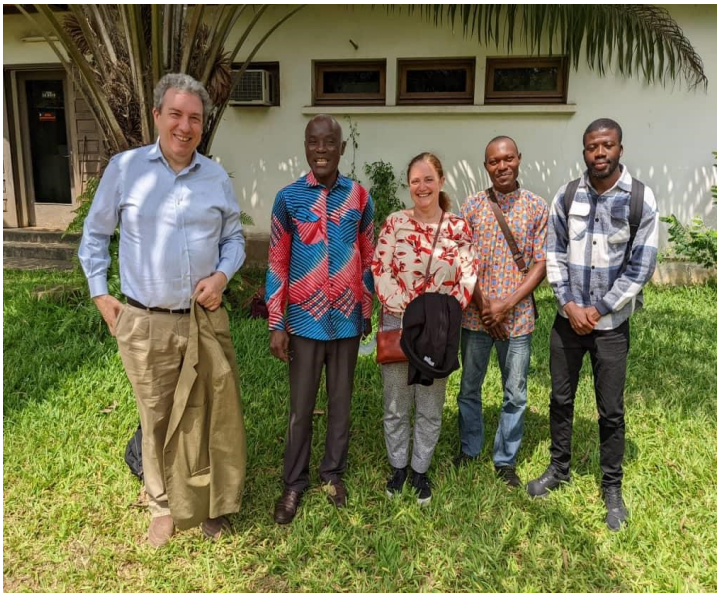

Figure 4. Farmer Charlie team with CNRA

Figure 5. Farmer Charlie CEO Betty Bonnardel with women working at the Boutique Paysanne, a renowned food store based in Abidjan. Boutique Paysanne sells products from smallholder farmers, especially women.

2.3 Outcome

The key achievements of our feasibility study concerned our improved knowledge of the needs of Côte d'Ivoire, some potential sales − as plantations have already expressed their needs −, our positioning as a credible provider of agri-tech solutions in Africa. Côte d'Ivoire is a promising target country, as it presents an open mind for business as well as opportunities in our main target markets, plantations, and community farming. Other outcomes include the potential opportunity for developing pilot tests of our solution in Côte d'Ivoire.

Last, but not least, the human-centered design approach coupled with questionnaires and in-house research allowed us to develop an increasingly user-friendly interface for our application, whose key features were reproduced on one pagers, which were provided to our stakeholders during the visit.

3. Sicily

3.1 The region

Located in the southernmost part of Italy and the largest island in the Mediterranean Sea, Sicily enjoys warm Mediterranean climate along the coasts with mild, moderately rainy winters and hot, sunny summers. In inland, hilly areas experience moderately cold winters and intense, often scorching hot summers, while in mountain areas, it is colder. Thanks to some local connections, Farmer Charlie got in touch with farming companies selling horticultural and citrus fruit products to supermarket chains in the country.

Challenges and needs of Sicilian farmers are of course different from those that were found in African countries, and the key issues here regarded irrigation, with the management of resources (water and energy) considered critical.

After several sessions spent with farmers and in the fields and greenhouses where the products are cultivated, we developed Farmer Charlie sensors tailoring them to the local features and we were able to install them in November 2021.

3.2. Current development

Our target development was to develop sensors which were good quality, at a very low cost and with a long life. We were pleased to have achieved success against our objective to develop a robust, interoperable, and low-cost system.

The equipment measured humidity and temperature in the field, connected to a weather station. The radio-module is based on a managed LoRA protocol, to bring efficiencies to our system.

Our data rate is narrow band, but we can also rely on radio modules which can transmit in broadband, would we require video, for instance.

Figure 6. Farmer Charlie installation in Sicily, Italy.

Conclusion

Farmer Charlie brings connectivity and information to farmers, who receive tailored agronomic data to improve their agricultural practice. Farmer Charlie is based on on-site sensors through which soil data can be detected, gathered, and processed by a dedicated server. Broadband communication allows farmers to receive real-time, localized information on tablet or mobile phone. Energy can be provided by solar panels and the data gathered by the system are delivered in real time through a user-friendly application, with an easy interface that can be adapted to the needs and requirements of users. Farmer Charlie is a low-cost solution; it can be adapted to various crops and can detect soil humidity, pH, temperature, whose knowledge permits to contain and balance the use of fertilizers, pesticides, and irrigation. These advantages can therefore positively impact the environment, which will benefit from lower carbon emissions, less waste, less pollutants. Farmer Charlie is a climate-friendly, sustainable solutions, which was conceived to respond to the issues faced by farmers in least developed countries – especially in remote areas, favoring fair trade and equitable commerce. Broadband dual communication also allows direct contact with farmers and efficient traceability, so that transparency is ensured over the supply chain. At present, the system is being tested in Sicily, Italy, where sensors have been installed and the team are working to optimize data collection delivery. Testing in Sicily is also the first step toward perfecting and offering Farmer Charlie in developed countries, where the needs and problems of farmers differ from those detected in DCs.

Tailored applications can also be hosted by the system, which offers a flexible open platform that can be integrated to achieve multiple aims. Overall, Farmer Charlie can be defined as a micro-agricultural solution that can be exploited on a big scale.

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Thanks to Innovate UK for trusting in us and supporting our studies and research by funding projects to develop Farmer Charlie.

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We would like to thank the International Society for Precision Agriculture for accepting our paper proposal and inviting us to present at the 15th International Conference for Precision Agriculture. This has been a fantastic opportunity to reflect on our work and to (proudly) realize how much we have achieved, despite the challenges posed by the pandemic, technical issues and limited funding and staff.

References

Anderson, J., et al. (2017). *National Survey and Segmentation of Smallholder Households in Nigeria*. CGAP. https://www.cgap.org/sites/default/files/publications/Working%20Paper_CGAP%20Smallholder%20Household%20Survey_NGA_Oct%202017.pdf. Last accessed 20 May 2022.

Danilola, S. T., et al. (2019). "Extent and financial cost of cassava postharvest loss along the cassava value chain in Kwara State, Nigeria". In *Acta Agriculturae Slovenica*, 114/2, 149-155, Ljubljana. https://pdfs.semanticscholar.org/a2f9/04163c869fa96d00d36eae04956c3487ab43.pdf?_ga=2.30501497.732662108.1653046801-1490070391.1653046801. Last accessed 20 May 2022.

Datareportal.com (2022). *Digital 2022: Nigeria Report*. https://datareportal.com/reports/digital-2022-nigeria. Last accessed 20 May 2022.

Ikuemonisan, E., et al. (2020). "Review of Cassava Production in Nigeria: Trends and Decomposition Analysis Approach". *Research Gate*, January 2020. https://www.researchgate.net/publication/347525080_Review_of_Cassava_Production_in_Nigeria_Trends_and_Decomposition_Analysis_Approach. Last accessed 20 May 2022.

International Telecommunication Union (2020), *Household Internet access in urban areas twice as high as in rural areas*. https://www.itu.int/en/mediacentre/Pages/pr27-2020-facts-figures-urban-areas-higher-internet-access-than-rural.aspx. Last accessed 20 May 2022.

Naidoo, P. (2020). "Nigeria Tops South Africa as the Continent's Biggest Economy". Bloomberg News, 3 March 2020.

Nicholson, K., et al. (2019). *Policy Dialogue. The role of governments in developing agriculture value chains*. CABRI. https://www.cabri-sbo.org/uploads/files/Documents/Case-Study-2_Rice-and-Cassava-ENG.pdf. Last accessed 20 May 2022.

Otekunrin, O. A., and-Sawicka, B. (2019). "Cassava, a 21st Century Staple Crop: How can Nigeria Harness Its Enormous Trade Potentials?". *Academia*. https://www.academia.edu/74265831/Otekunrin_and_Sawicka2019_pdf. Last accessed 20 May 2022.

Oyegbami, A. (2018). "Location and Distance of Farmers to Agricultural Extension Service: Implication for Agricultural Development in Oyo State, Nigeria". *South African Journal of Agricultural Extension*, Vol. 46, No. 2, 14-23. www.scielo.org.za/pdf/sajae/v46n2/02.pdf. Last accessed 20 May 2022.

Oyo State Government (2022). *About Oyo*. https://oyostate.gov.ng/about-oyo-3. Last accessed 20 May 2022.

Romero, S., et al. (2012). *AgriGuide Roots and Tubers*, p.53. ICV. www.agriguide.org/agriguide/files/etic_agriguide_en_20120830.pdf. Last accessed 20 May 2022.

World Atlas (2022), *Sicily*. https://www.worldatlas.com/articles/biggest-islands-in-the-mediterranean-sea.html. Last accessed 20 May 2022.

World Bank, The (2020), *Nigeria*. https://data.worldbank.org/country/nigeria?view=chart. Last accessed 20 May 2022.