Application of Smart Technologies in Cadastral Surveying of Large Areas in Ghana.

QUAYE-BALLARD, Naa Lamkai (Ghana), ASENSO-GYAMBIBI, Daniel (Ghana), QUAYE-BALLARD, Jonathan Arthur (Ghana), YEBOAH, Eric (Ghana) and ASAMOAH Asante Benedict (Ghana)

Keywords: Cadastral Surveying, Google Earth, Mobile Topographer Application, Open Data Kit Mobile Applications, Land Information System (LIS)

SUMMARY

Smart technologies are no exception in Cadastral Surveying for fast and cost-effective cadastral plan production. Cadastral plans are the basic documentation for land ownership in Ghana. Accurate cadastral plan of land improves the land administration system and prevents land disputes. By incorporating smart technologies, this study surveyed twenty-one thousand acres of land in the Jomoro District of the Western Region, Ghana, with mountainous terrain full of lush vegetation and farms and bounded by the sea at one side. The objective of the study was to produce a cadastral plan and collect auxiliary data on stool land, farmland ownership and selected buildings for Land Information System (LIS). Smart technologies used include Mobile Topographer and Open Data Kit (ODK) android applications, Google Maps and Google Earth. During the reconnaissance survey, the digitized proposed plan of the area was superimposed in Google Earth software and pillar points were generated. Using the Google Earth mobile application, these points were set out on site. Local personnel were trained with the use of Mobile Topographer and ODK applications to aid in data collection of auxiliary data for LIS. Unmanned Aerial Vehicle (UAV) mapping was conducted to produce additional data for LIS. The final developed cadastral plan was approved and endorsed by Survey and Mapping Division (SMD), Lands Commission, Ghana. By incorporating smart methodologies, the proposed duration of twenty months reduced to four months with reduced operational cost. The approach proved effective and efficient for producing Cadastral plans for large areas where timely data acquisition is required for policy making and development.

Application of Smart Technologies in Cadastral Surveying of Large Areas in Ghana.

QUAYE-BALLARD Naa Lamkai (Ghana), ASENSO-GYAMBIBI Daniel (Ghana), QUAYE-BALLARD Jonathan Arthur (Ghana) YEBOAH, Eric (Ghana) and ASAMOAH Asante Benedict (Ghana)

1 INTRODUCTION

Cadastral surveying has been defined by (DES GÉOMÈTRES, F.I., 1995) as "the definition, identification, demarcation, measuring and mapping of new or changed legal parcel boundaries." The main highlights of Statement 3 and 4 on Cadastre 2014, were digitalization, modelling of objects according to data models and storage in information systems. It also mentioned the need for real low-cost solutions for cadastre would be possible when the above technology is used in combination with lean administrative procedures (Kaufmann, *et al*., 1998). Smart technologies are no exception in Cadastral Surveying for fast and cost-effective Cadastral plan production. Accurate cadastral plan of land improves the land administration system and prevents land disputes (Yomralioglu *et al*., 2017).

Cadastral plans are the basic documentation for land ownership in Ghana. In Ghana, Cadastral mapping is conducted in accordance with formats and standards of the Survey and Mapping Division (SMD) of the Lands Commission of Ghana. Under the Survey Act 1962 (Act 127) a Licenced Surveyor is required to conduct and supervise Cadastral Surveying and submit for approval by Director of Surveys of SMD. Cadastral Surveying in Ghana follows technical instructions by the SMD to obtain coordinates within the Ghana National grid system, draw a plan and get it approved by SMD (Akrofi *et al*., 2009). Locating boundary points for constructing pillars by cutting survey lines and attaining intervisibility in areas with vegetation cover is a daunting task. Cost of labour is usually high as labourers are employed to clear the land areas, sometimes destroying farm lands. These practices increase the duration of Cadastral Surveying of large areas with vegetation cover (Quaye-Ballard *et al*., 2020). Data collection methodologies, for large areas for comprehensive Land Information System (LIS) to aid valuation, effective land acquisition and development is also a time-consuming task.

With technological advancement, Land Surveyors are finding easier way of conducting Cadastral Surveying to produce cost effective cadastral plans to improve the land administration system in Ghana. The use of mobile application in data collection and mapping are modern trends that are being used to improve surveying. Google Earth uses satellite imagery to represent the earth in 3D (Lyle *et al*., 2010). Coordinates of all places on the earth as well as distances and areas of various locations can be obtained using Google Earth. Various studies nationally and internationally employed Google Earth, Mobile Topographer and Open Data Kit (ODK) android applications for mapping and data collection. For example, Lyle *et al*. (2010) studied on the conversion of cadastral data to KML file type for use in Google Earth and Google Maps for mobile as a land information system. Bokonda *et al*. (2019) researched on Open Data Kit (ODK) mobile data collection framework for developing countries.

Ogundipe (2013) investigated the use of smart phone as a surveying tool. Park *et al*. (2013) developed an Android-based application for total station surveying and visualization using smartphone and Google Earth. The Mobile Topographer application uses the GPS trackers in mobile devices to obtain location information and communicate with multiple satellites in space via radio signals. Examples of studies that employed the Mobile Topographer for mapping include Sutanta and Wulandari (2019), Kusbiantoro *et al.* (2020), Rahayu *et al.* (2018) and Yadav and Bhardwaj (2021). In addition, the Open Data Kit (ODK) android application has been used to capture, store, edit and transmit field data (Signore, 2016; Tom-Aba *et al., 2015;* Loola Bokonda *et al., 2019*; Ouma *et al., 2019* and Macharia *et al., 2013*). The use of Unmanned Aerial Vehicles (UAVs) for remote data acquisition has rapidly evolved in recent years since its integration with Global Positioning System (GPS); and Geographic Information System (GIS) techniques have reduced time and cost in acquiring data for inaccessible land areas (Quaye-Ballard *et al*., 2020).

This study surveyed twenty-one thousand acres of land in the Jomoro District of the Western Region, Ghana with mountainous terrain full of lush vegetation and farms bounded by the sea at one side by incorporating smart technologies. The objective of the study was to produce a cadastral plan and collect auxiliary data for a comprehensive Land Information System to aid valuation, effective land acquisition and development. To achieve this, Google Earth, Mobile Topographer and Open Data Kit (ODK) android applications, and UAV mapping were employed in this study.

2 METHODOLOGY

The methods and data process adopted for the study is shown in Figure 1.

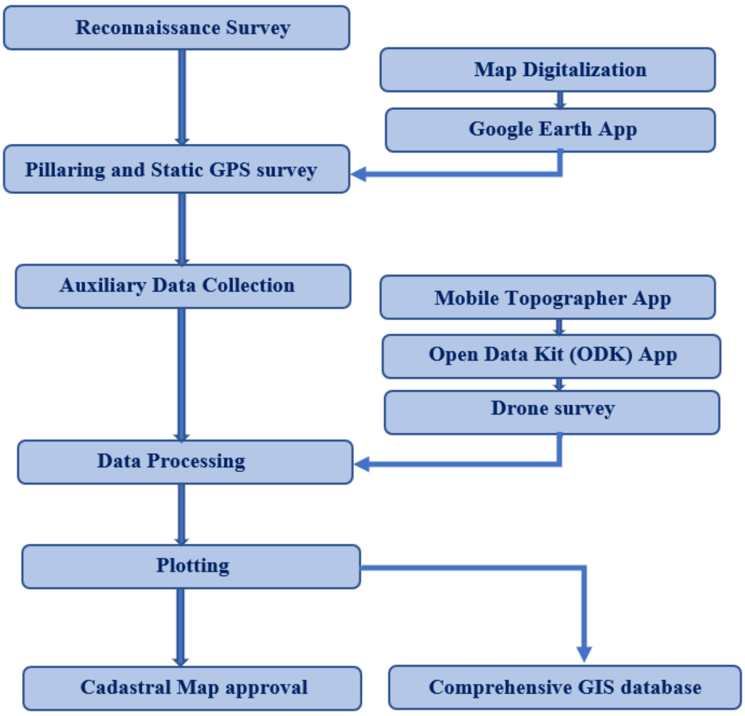

Figure 1: Flow chart methods and data processing

2.1 Reconnaissance survey

A site visit was done to plan the best way to undertake the studies. The SMD of the Lands Commission of Ghana was visited to seek locations and coordinates of National Benchmarks closer to the study location. A desk study was done by studying Google and Topographical maps of Ghana. A paper map showing boundaries of the study area was obtained from Land Use and Spatial Planning Authority Ghana (LUSPA) and digitized. The study team mobilized Static GPS, UAV and handheld GPS in preparation for the survey.

2.2 Map Digitization

Preliminary boundary data of the study area obtained from LUSPA was in the form of paper map with grid lines and coordinates referenced to the Ghana National Grid coordinate system. It was then scanned into an image and imported into Quantum GIS (QGIS) software. Coordinates for eight (8) grid intersections were generated from the paper map to be used as control points for georeferencing. The scanned image was georeferenced using the Georeferencer GDAL plugin of QGIS software.

After georeferencing, polygon shapefiles were created with QGIS software and were projected in the Ghana National Grid coordinate system. The digitizing tool was used to trace the proposed boundary of the study area from the scanned image. The shapefile containing the boundary was converted to a Keyhole Mark-Up Language (KML) file in the WGS84 system. These were imported into the Google Earth mobile application (Figure 2). The KML file was imported into the Google Earth platform on a GPS-supported smartphone using the file import function. The location of the smartphone was turned on in order to know the observer position at any point in time. The measure tool in the Google Earth application was used to measure the distance of the current location of the surveyor to a destination point (Figure 3). A total of twenty-six points were located.

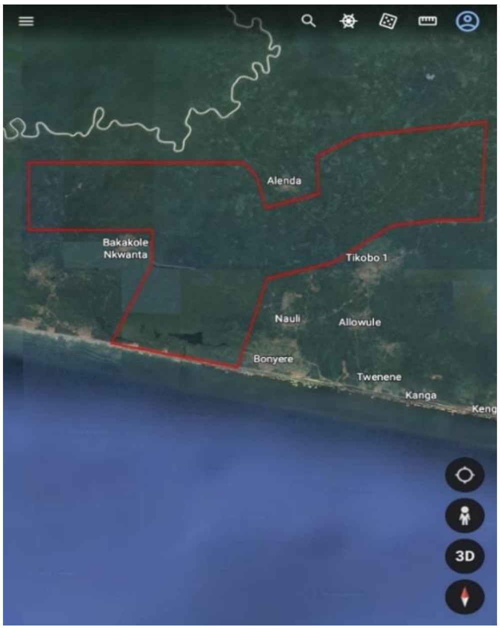

Figure 2: Google Earth Mobile App showing study area

Figure 3: Navigation using Google Earth application

2.3 Pillaring and Static GPS survey

Upon locating points using the mobile Google Earth application, the pillars were constructed. In-situ concrete pillars were constructed with iron rods at the centre (Figure 4). The pillars were labelled in accordance with regional number system of SMD (Figure 5). Pillars were constructed at all twenty-six points. A static GPS survey using dual frequency receiver commenced from known benchmarks provided by SMD. The base was mounted on a known benchmarks and the rover was placed on the pillars to observe at a minimum of thirty minutes. (Figure 6).

Figure 4: Construction of concrete pillar

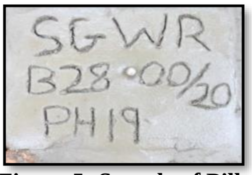

Figure 5: Sample of Pillar

Figure 6: Static GPS mounted on pillar

2.4 Mobile Topographer and Open Data Kit (ODK) for Auxiliary Data Collection

In order to produce a comprehensive Land Information System (LIS) for the study area to compliment the cadastral plan and aid valuation, effective land acquisition and development, auxiliary data was collected on stool land, farmland ownership and selected buildings. The team involved the townsfolks in various sensitization exercises and training. A total of thirty townsfolks were employed as local data collectors to aid in the collection of the auxiliary data. (Figures 7 and 8). The local data collectors were selected based on the fact that they owned android telephones and easily grasped the concept of the survey. Mobile Topographer and ODK android application which are available for free download were downloaded on data collectors' mobile telephones and trained in the usage.

Figure 7: Training of local data collectors

Figure 8: Sensitization workshop for townsfolks

Mobile Topographer application uses the GPS trackers in mobile devices to obtain location information. The GPS trackers in the mobile devices communicate with multiple satellites in space via radio signals. The application then uses the signals received from the satellites to compute the location of the device. The maximum error value was set at one (1) meter. For the boundary survey, the local data collectors were divided into teams over the study area. The Mobile Topographer application was used to pick points along the boundary of a farm/land shown and agreed by the town's representative in the presence of neighbouring farm/land owners (Figure 9). The application stored the data of each boundary separately and exported in excel csv format at the close of work for data processing.

Figure 9: Sample data of Mobile Topographer App

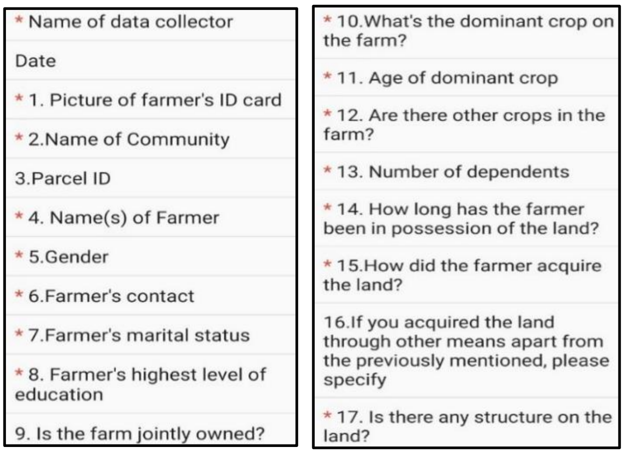

Figure 10: ODK App questionnaire

The Open Data Kit (ODK) android application was customized to capture, store, edit and transmit the field data onto a cloud server. ODK application is simple, flexible and a smart tool for collecting field data. A questionnaire was developed to collect information of farm/land ownership with the ODK application for easy documentation of land and farm owners (Figure 10). Land owners were informed of the questionnaire during the sensitization programme. An opinion leader was contracted to ensure farmers and land owners understood the requirements and questions to be asked. They interviewed land and farm owners and filled the questionnaire, saved it and uploaded to the ODK server. Five Geomatic Engineers were tasked to process the data uploaded at the close of each day and compiled in excel and later assigned as attribute data to the corresponding boundary map in GIS.

2.5 UAV Survey

A consumer grade UAV was used to capture selective buildings that were within the study area for LIS. Flight plan was designed to determine the area and path for the UAV survey. The UAV was set to enhanced 3D mode. The selected flight height was seventy-five (75) metres. Ground control points were fixed and surveyed with Static GPS to obtain coordinates for georeferencing.

3 RESULTS AND ANALYSIS

The Google Earth application helped the team to choose the shortest feasible distance to locate points on site. The team easily navigated through trails, footpaths and farm routes using two-wheel motorcycles (Figure 11a) and three-wheel cargo motorcycles (Figure 11b) to get closer to the points. There was minimal cutting of lines to access points which were either along the shoreline, in farms or forest reserves and therefore reduced duration and cost. Accuracy of the points located were below five metres. This was largely due to the small-scale nature of the map, map generalization and digitization. Mobile data connection was not consistently available in the outskirts of towns and limited the usage of the mobile applications. However, The Google Earth application could be used offline with the location on mobile devices to navigate to pillar points. Two pillar points had to be readjusted by twenty (20) metres due to the fact that their initial positions were in marshy mangrove. Some data collectors had weak mobile telephone batteries. They were however provided with power banks to take along to recharge their telephones in off grid areas. Sensitization effort was minimal in some remote towns and villages which caused initial agitation among townsfolks. This was resolved through the opinion leaders who were part of the study team to address such issues.

Figure 11: (a) Motorcycle to access pillar points; and (b) Three-wheel cargo motorcycles to access pillar points

The coordinates of pillars were downloaded from the GPS, processed and the boundary was plotted in GIS to assign the auxiliary data. Coordinates from the Mobile Topographer were processed and plotted in QGIS on the boundary map of the study area. There was cleaning of data since most data collectors were having challenges uploading data to the server or uploaded data with gross errors. This accounted for 9% of the auxiliary data which were excluded from the final output. The overall ease of farm/land boundaries data capture reduced the duration of the study since there were more local teams who related well with their indigenes and also understood the use of the application. The ODK application made it easier to compile attribute data of farmers/ land owners and stored easily on the ODK server. Data was easily accessed, downloaded and processed into a comprehensive attribute data (Figure 12). The boundary data of farms were represented on the boundary map (Figure 13).

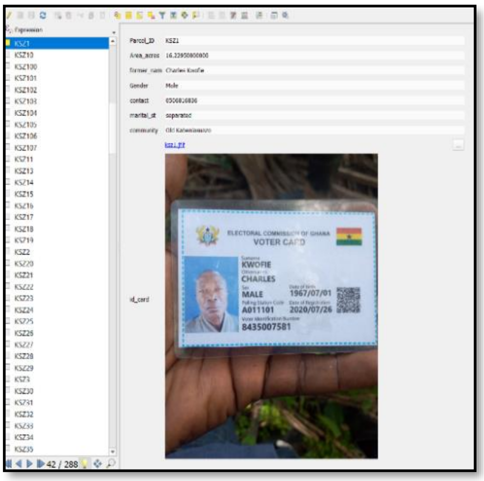

Figure 12: Sample of ODK App

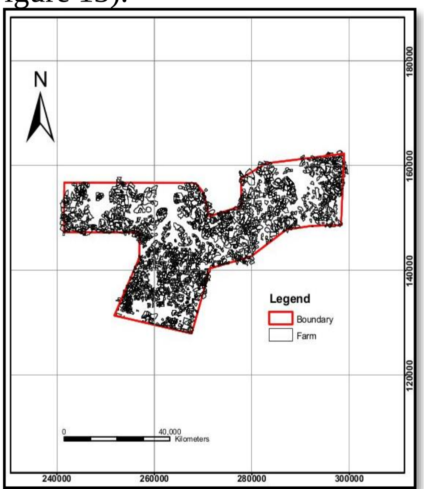

Figure 13: Map showing Auxiliary

A total of two thousand and sixty-five farm boundary and data were collected and analyzed in QGIS. The orthophoto derived from processing UAV image captured on selected buildings was used to innumerate and identify structures that are of interest within the study area (Figure 14).

Figure 14: Orthophoto of selected buildings

The Cadastral plan was plotted in the required format and standards of the Survey and Mapping Division (SMD) of the Lands Commission of Ghana. The plan was then printed and approved by the Regional Surveyor of Western Region. A total of twenty thousand, five hundred and thirteen acres was surveyed. The Cadastral plan produce for approval is as shown in Figure 15.

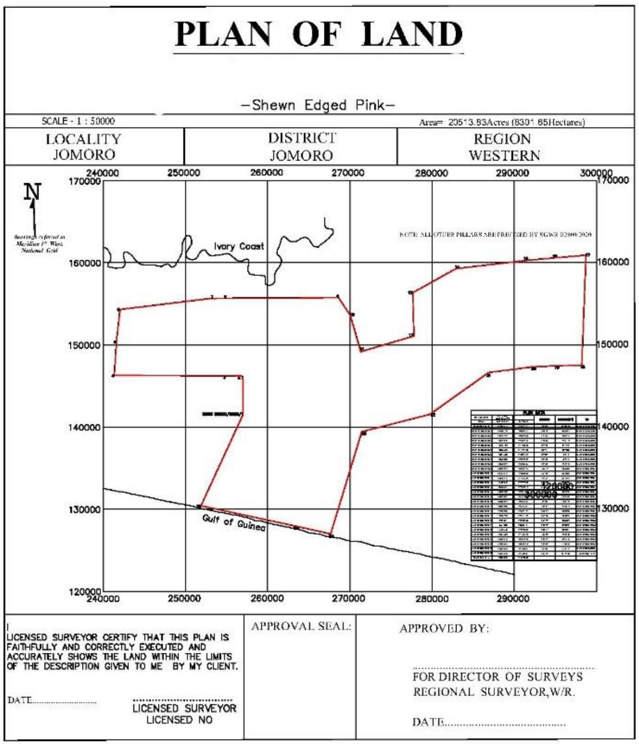

Figure 15: Cadastral plan before approval

4 CONCLUSIONS AND RECCOMMENDATIONS

Cadastral plan of large areas can be accomplished in lesser duration when smart methodologies are incorporated in the planning and data collection process. Mobile applications are easily understood by non-technical people, cheaper and faster way of auxiliary data collection for LIS. LIS makes acquisition and valuation survey easier and reduces land disputes. LIS provides a visual geographic information for Valuers, Environmentalist, Engineers and Planners to plan, design and execute developmental projects.

Incorporating smart methodologies significantly reduced the proposed duration of about twenty months (using conventional methods) to four months with reduced operational cost. The approach proved effective and efficient for producing Cadastral plans for large areas where timely data acquisition is required for policy making and development. Smart methodologies are recommended to aid Land Surveyors easily conduct Cadastral surveying and collect auxiliary data for LIS to improve land management. Further studies on the use of LIS in land valuation and land title registration in Ghana is recommended. The SMD must also revise their laws to fully incorporate the application of smart technologies.

5 ACKNOWLEDGEMENT

The study team extends appreciation to Surv. Mark Kakraba Ampeh for his immense contribution to this study. We also appreciate the people of the Jomoro District of the Western Region, most importantly, Mr. Emmanuel Nvojo, the liaison lead and the LUSPA staff of Half Asini. We are grateful to the people of Old Kabenlesuazo, whose hospitality made our stay memorable in the Jomoro District. We are most grateful to CSIR-BRRI for the contribution in making this study a success.

6 REFERENCES

Akrofi, O. and Ayer, J., 2009. Equipping and recognising the cadastral surveyor's role in development information in Ghana'. Geo Spatial World. Anim-Odame, W., 2018. *Land Administration in Ghana: The New Agenda* (No. afres2018_111). African Real Estate Society (AfRES).

Asiama, K., Bennett, R. and Zevenbergen, J., 2018. Participation, innovative approaches and customary cadastres: A practical experiment in Nanton, Ghana. In *World Bank Conference on Land and Poverty 2018: Land Governance in an Interconnected World* (pp. 19-23).

Brinker, R.C. and Minnick, R. (1995). The surveying handbook. 2nd Edition, Chapman & Hall. Berlin/Heidelberg, Germany

Bokonda, P.L., Ouazzani-Touhami, K. and Souissi, N., 2019. Open Data Kit: Mobile Data Collection Framework For Developing Countries. *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, *8*(12), pp.4749-4754.

DES GÉOMÈTRES, F.I., 1995. Statement on the Cadastre. *International Federation of Surveyors*

Gupta, A., Jatin T., Amarjeet S., Pushpendra S., Vivek S., and Vibhore V.. "Simplifying and improving mobile based data collection." In *Proceedings of the Sixth International Conference on Information and Communications Technologies and Development: Notes-Volume 2*, pp. 45-48. 2013.

Kaufmann, J., 2017. From a traditional to a comprehensive cadastre. In Cadastre: Geo-Information Innovations in Land Administration

Kaufmann, J. and Steudler, D., 1998. A vision for a future cadastral system. *Scientific Research*, pp.167-173.

Kohli, D., Bennett, R., Lemmen, C., Asiama, K. and Zevenbergen, J., 2017. A Quantitative Comparison of Completely Visible Cadastral Parcels Using Satellite Images: A Step towards Automation. In *Proceedings of the FIG Working Week* (pp. 1-14).

Kusbiantoro, K., Lesmana, C. and Vanessa, I., 2020. Hybrid Approaches in Cultural Heritage Reconstruction of Chinese Lieutenant Tomb in Bandung: A Multidisciplinary Survey. *Innovation Research in the ERA of MBKM*; p.105.

Liang, J., Gong, J. and Li, W., 2018. Applications and impacts of Google Earth: A decadal review (2006–2016). *ISPRS Journal of Photogrammetry and Remote Sensing*, *146*, pp.91-107.

Li, Q., Qiu, C., Ma, L., Schmitt, M. and Zhu, X.X., 2020. Mapping the land cover of Africa at 10 m resolution from multi-source remote sensing data with Google Earth Engine. *Remote Sensing*, *12*(4), p.602.

Loola Bokonda, P., Ouazzani-Touhami, K. and Souissi, N., 2019. Mobile Data Collection Using Open Data Kit. In *International Conference Europe Middle East & North Africa Information Systems and Technologies to Support Learning* (pp. 543-550). Springer, Cham.

Lyle, S.D. and Eby, N., 2010. Conversion of cadastral data to KML file type for use in Google Earth and Google Maps for Mobile as a land information system. In *Proceedings of the 1st International Conference and Exhibition on Computing for Geospatial Research & Application* (pp. 1-4).

Macharia, P., Muluve, E., Lizcano, J., Cleland, C., Cherutich, P. and Kurth, A., 2013. Open Data Kit, A solution implementing a mobile health information system to enhance data management in public health. In *2013 IST-Africa Conference & Exhibition* (pp. 1-6). IEEE.

Mantey, S., 2019. Suitability of Unmanned Aerial Vehicles for Cadastral Surveys. *Ghana Mining Journal*, *19*(1), pp.1-8.

Ogundipe, O., 2013. The Smart Phone as a Surveying Tool. TS03C Position. Navig. Today Tomorrow, 6626, pp.1-11.

Ouma, T., Kavoo, A., Wainaina, C., Ogunya, B., Karanja, M., Kumar, P.L. and Shah, T., 2019. Open data kit (ODK) in crop farming: Mobile data collection for seed yam tracking in Ibadan, Nigeria. *Journal of Crop Improvement*, *33*(5), pp.605-619.

Park, J., Lee, S. and Suh, Y., 2013. Development of an Android-based app for total station surveying and visualization using smartphone and Google Earth. Korean Journal of Remote Sensing, 29(2), pp.253-261.

Quaye-Ballard, N. L., Asenso-Gyambibi, D. and Quaye-Ballard, J. (2020). Unmanned Aerial Vehicle for Topographical Mapping of Inaccessible Land Areas in Ghana: A Cost-Effective Approach, in FIG Working Week 2020 Smart surveyors for land and water management. Conference Proceedings. Amsterdam, the Netherlands, 10–14 May 2020, p. 14.

Rahayu, S., Adi, M.S. and Saraswati, L.D., 2018. Mapping of leptospirosis environmental risk factors and determining the level of Leptospirosis vulnerable zone in Demak District using remote sensing image. In *E3S Web of Conferences* (Vol. 31, p. 06003). EDP Sciences.

Tom-Aba, D., Olaleye, A., Olayinka, A.T., Nguku, P., Waziri, N., Adewuyi, P., Adeoye, O., Oladele, S., Adeseye, A., Oguntimehin, O. and Shuaib, F., 2015. Innovative technological approach to Ebola virus disease outbreak response in Nigeria using the open data kit and form hub technology. *PloS one*, *10*(6), p.e0131000.

Signore, A., 2016. Mapping and sharing agro-biodiversity using open data kit and google fusion tables. *Computers and Electronics in Agriculture*, *127*, pp.87-91.

Sutanta, H. and Wulandari, M.D., 2019. Mapping the distribution network of a government non-cash food assistance in Kulon Progo Regency using geospatial information system. In *IOP Conference Series: Earth and Environmental Science*, 389(1); p. 012053. IOP Publishing.

Yadav, U. and Bhardwaj, A., 2021. Accuracy Assessment of Openly Accessible CartoDEM V3 R1 and TanDEM-X 90 Using A Smartphone with Assisted GPS for Ratlam City and Surroundings. *Engineering Proceedings*, *10*(1), p.64.

Wilkowski, W. and Karabin, M., 2006, October. Cadastre 2020–a vision for a future cadastral system in Poland. *In XXIII FIG Congress* (pp. 8-13).

Yomralioglu, T. and McLaughlin, J. eds., 2017. *Cadastre: Geo-Information innovations in land administration* (Vol. 335). Cham, Switzerland: Springer.

BIOGRAPHICAL NOTES

Surv. Ing. Naa Lamkai Quaye-Ballard
Surv. Ing. Mrs. Naa Lamkai Quaye-Ballard is a researcher with interest in geospatial technologies and sustainable public transportation. She is currently a Researcher with the Council for Scientific and Industrial Research (CSIR) - Building and Road Research Institute (BRRI), Ghana and pursuing her doctorate degree at KNUST. Having worked as a consulting Geodetic Engineer in Ghana for over fifteen (15) years, she has supervised a lot of projects, notable among them are the construction of the Evans Atta Mills High Street, Accra and Lake Road Interchange, Kumasi. She is a Council Member of Ghana Institution of Engineering (GhIE), Chair of Research and Awards Committee of GhIE, Council Member of Women in Engineering Ghana (WinE). She is a committee member of the Women in Engineering of the Federation of African Engineers (FAEO). She is also a professional member of Ghana Institution of Surveyors (GhIS).

Surv. Ing. Dr. Daniel Asenso-Gyambibi
Surv. Ing. Daniel Asenso-Gyambibi is the Director of the CSIR-BRRI, Ghana. His research areas are land administration, GIS and Mapping. He has twenty-three (23) years work experience, working on a number of projects of national importance including the Ghana Lana Administration Project (LAP), mapping of degraded mine site and reclamation activities, preparation of schemes for urban renewal, perfecting rural land title, hydrographic surveys, mine surveys, GIS in health, transport, mining and agricultural development etc. Daniel's wide experience is as a result of his involvement in projects with varied professionals in the Built Environment. He holds A doctorate, an MPhil and BSc in Geomatic Engineering from the Kwame Nkrumah University of Science and Technology, Ghana. He is a member of Ghana Institution of Surveyors and Ghana Institution of Engineering.

Surv. Ing. Prof. Jonathan Arthur Quaye-Ballard
Jonathan Arthur Quaye-Ballard is an Associate Professor and Head of Department of Geomatic Engineering, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana. Nineteen (19) years working at KNUST till present. Holds BSc. Geodetic Engineering from KNUST, Kumasi, Ghana; MSc. Geo-Information Science and Earth Observation from ITC, Enschede, The Netherlands; and PhD. Geodesy and Survey Engineering from Hohai University, Nanjing, China. A Licensed Surveyor and member of Ghana Institution of

Surveyors (GhIS) and Ghana Institution of Engineering (GhIE). Research interest are Usability Testing; Applications of Geographic Information Systems (GIS) and Remote Sensing (RS) for environmental resource management and analysis; Cartographic Visualization; Systems Analysis; and Computer Supported Collaborative Learning (CSCL).

Surv Dr. Eric Yeboah

Surv Dr. Eric Yeboah is a Senior Lecturer in Land Economy and Land Administration at the Department of Land Economy, KNUST. He is currently a Senior Land Policy Advisor at the office of the Senior Presidentrial Advisor, Office of the President Ghana. He was also a visiting Lecturer in International Land Management, Technical University of Munich, Germany from June 2016 to May 2019. He is a number of land related technical committees and infrastructure committees. Dr Yeboah holds a PhD in Land Management from University of Leeds and BSc in Land Economy form KNUST. He was recognised as an emerging leader in 2009 by thge Foreign and Commonwealth Office of the United Kingdom under the International Leadership programme**.**

Mr. Benedict Asamoah Asante

Mr. Benedict Asamoah Asante is a Geomatic Engineer at CSIR-BRRI, Ghana. His research area is GIS and Mapping. He has five (5) years work experience and has worked on projects such as Land Acquisition for Ghana’s proposed Petroleum Hub, Mapping of all Ghana Education Trust Fund projects in the Northern region of Ghana, Mine Surveys, GIS for Land Administration, UAVs and GIS for Surveying and Mapping, etc. He holds a Bachelor of Science in Geomatic Engineering and MPhil GIS candidate at KNUST.

CONTACTS

Surv. Ing. Naa Lamkai Quaye-Ballard

Council for Scientific and Industrial Research (CSIR) - Building and Road Research Institute (BRRI), P. O. Box UP40 Kumasi, Ghana

Tel.: +233 24 4723664; E-mail: naalamkaig@gmail.com

Surv. Ing. Dr. Daniel Asenso-Gyambibi

Council for Scientific and Industrial Research (CSIR) - Building and Road Research Institute (BRRI), P. O. Box UP40 Kumasi, Ghana

Tel.: +233 24 4255859; E-mail: danasenso@gmail.com

Surv. Ing. Prof. Jonathan Arthur Quaye-Ballard

Department of Geomatic Engineering, KNUST, Kumasi, Ghana

Tel.: +233 27 7474073; Email: quayeballard.soe@knust.edu.gh; website: www.knust.edu.gh

Surv Dr. Eric Yeboah

Department of Land Economy, KNUST, Kumasi, Ghana

Tel: +233 509825619; E mail: eryckyeboah@yahoo.com

Mr. Benedict Asamoah Asante

Council for Scientific and Industrial Research (CSIR) - Building and Road Research Institute (BRRI), P. O. Box UP40 Kumasi, Ghana Tel.: 233 55 5004019; Email: padomiski@gmail.com