UNIVERSITY OF CAPE COAST

SEISMOLOGICAL, METEOROLOGICAL AND GEOCHEMICAL INVESTIGATION FOR EARTHQUAKE HAZARD IN THE GREATER ACCRA METROPOLITAN AREA

MAXIMILLIAN-ROBERT SELORM DOKU

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BY

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: .... Date: ....

Name: Maximillian-Robert Selorm Doku

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature: ………………. Date: ....

Name: Prof. Paulina Ekua Amponsah

Co-Supervisor's Signature: .... Date: ....

Name: Prof. Frederick Sam

ABSTRACT

Seismological, Meteorological and Geochemical investigations for earthquake hazard were carried out in the Greater Accra Metropolitan Area (GAMA). An earthquake catalogue generated was used to calculate the b-value (seismic stress) by the Linear Least Square (LLS) method and the Maximum Likelihood Estimation (MLE) method. The Geographic Information System (GIS) was used to generate epicentral intensity and isoseismal maps from the catalogue. The meteorological investigation involved the use of precipitation data from the coastal belt of the synoptic stations of the Ghana Meteorological Agency (plotted with the seismic data to identify possible correlation). The isotopic anomaly analysis to investigate the geochemical effect was done by evaluating radon concentrations in soil gas and water using the Solid State Nuclear Track Detector (SSNTD) and the Electret Passive Environmental Radon Monitor (EPERM®). Detectors were buried at Tema, Ashaiman, Weija, Donkunah and Kwabenya over a one-year period (January 2018 to December 2018). An average b-value of 0.63 was evaluated by the LLS Method and 0.88 for the MLE Method. The epicentral intensity, frequency and isoseismal maps show a detailed distribution of earth tremors of magnitudes less than 5 M_w. The meteorological investigation shows a not very strong Pearson's correlation coefficient of precipitation with seismicity (r=0.4 and p-value=0.04). Geochemical investigations also show a very weak positive Pearson's Correlation Coefficient of radon emanation and seismicity (r=0.1 and p-value=0.69).

KEY WORDS

Catalogue

Earthquake

Geochemical

Hazard

Meteorological

Seismological

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DEDICATION

To my father, Tornyi Doku Ayikah

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LIST OF ABBREVIATIONS

ALY	Leydecker and Amponsah (1986)
AMA	Accra Metropolitan Assembly
AMB	Ambraseys and Adams (1986)
AMP	Amponsah (2008)
CBF	Coastal Boundary Fault
CIGTM	Cote D'Ivoire – Ghana Transform Margin
CTBTO	Comprehensive Nuclear Test Ban Treaty Organization
DNA	Deoxyribonucleic Acid
DYFI	Did You Feel It
EPERM	Electret Passive Environmental Radon Monitor
GAEC	Ghana Atomic Energy Commission
GAMA	Greater Accra Metropolitan Area
GBC	Ghana Building Code
GGSA	Ghana Geological Survey Authority
GIS	Geographical Information System
GPS	Global Positioning System
GSD	Geological Survey Department
IRIS	Incorporated Research Institutions for Seismology
IRSA	Increased Reactive Surface Area
ISC	International Seismological Centre
KNUST	Kwame Nkrumah University of Science and Technology
LLS	Linear Least Square
MATLAB	Matrix Laboratory
M_b	Body-wave Magnitude Unit

M_D	Duration Magnitude Unit
MLE	Maximum Likelihood Estimation
M_L	Local Magnitude Unit
MM	Surface-Wave Magnitude for macroseismal data
M_o	Seismic Moment
M_s	Surface-wave Magnitude
M_w	Moment Magnitude Unit
NADMO	National Disaster Management Organization
NDC	National Data Centre
NNRI	National Nuclear Research Institute
PF	Pan-African Front
PGA	Peak Ground Acceleration
PGV	Peak Ground Velocity
PVC	Polyvinyl Chloride
SSNTD	Solid State Nuclear Track Detector
USA	United States of America
USGS	United States Geological Survey
WAC	West African Craton
WNW	West North West
WSW	West South West
WWSSN	World Wide Standard Seismograph Network

CHAPTER ONE

INTRODUCTION

Background to the Study

Immunity from disaster and disaster related loss is impossible on earth. The ability to minimize the degree of damage when they do happen is however very possible. Situations or occurrences that pose a degree of danger to our property, environment or life are often described as disasters. Natural hazards and man-made disasters have plagued the earth and the built environment for a very long time. There are various exposures or vulnerabilities to risks (hazards). Fires, floods, tropical cyclones, earthquakes, tsunamis, hurricanes and other environmental related disasters are natural hazards (Amponsah, 2004). When hazards occur in regions having low vulnerability, they usually do not result in disasters (Allottey et. al., 2010).

In high-vulnerability areas like the Greater Accra Metropolitan Area (GAMA), studies have shown that natural and man-made hazards are frequently accompanied by deadly forces or retribution (Doku et. al., 2014). A lot of man-made hazards are linked to industry, transportation and health. Internal earth processes such as tectonic movements, isotopic emissions and volcanic eruptions as well as related geological processes like landslides, mass movements, surface collapse and mudflows are all natural hazards.

Common disasters in Ghana include earthquakes, epidemics, storms, mass movements, extreme temperatures, floods, insect infections, etc. (Amponsah, 2004) These disasters have been fairly mitigated by the National Disaster Management Organization (NADMO) assisted by other agencies. In the Vrancea Zone, Romania, many attempts have been made to scientifically link seismicity to a variety of precursors in seismically active areas (Ioane & Stanciu, 2017).

By comparing seasonal rainfall data of about 90 years with the occurrence of earthquakes along an arid stretch of the San Adreas fault system in Southern California, certain correlations have been established. The writers observe that major tremors and earthquakes are preceded by varying degrees of high precipitation (Huang et. al., 1979).

The effect on seismic activity of the existence and management of man-made water reservoirs has previously been dealt with in many articles. Some of these include the first observations made at Hoover Dam in 1941 by Mead and Garder and precipitation induced seismicity investigation in the 1967 destructive earthquake at Koyna, India. Here, the writers concluded that a magnitude 6.5 earthquake in the vicinity of Lake Kinnereth caused great damage and had many casualties. It occurred 20km north of the lake (Kafri & Shapira, 1990).

The main cause of increased seismicity in the Vrancea zone in the spring and autumn was determined to be caused by heavy precipitation and/or snow melting in these areas. It was observed that water infiltrates deeper into the earth, increasing activity along active faults (Ioane & Stanciu, 2017).

Earthquakes are major threats to humanity and it is a great challenge for scientists and engineers to make efforts to prevent their disastrous consequences (Sultankhodjajev, 1984). As humans most of our activities depend on seismo-tectonic, geo-dynamic or geochemical conditions and events. Monitoring radon emanation and counting the tracks by the etching method has helped to relate earth tremors, earthquakes and landslides to isotopic anomalies (geochemistry) (Sac et. al., 2013; Sigaran-Loria et. al, 2007).

Pore water does control seismic stress release. Recognizing pore water as a triggering factor cannot be overemphasized. It is a well-established fact that GAMA’s microseismic events are usually close to the Akuapem fault zone and the coastal boundary faults especially at their intersections, off the Romanche fracture zone (Doku et. al., 2014; Sykes, 1978).

The relationship between radon anomalies and seismic activity in Tuzla fault Zone in Western Turkey was investigated and proven to be related. It was observed that seismic activity across the world required the investigation and development of new methods for predicting earthquakes. Variations of radon gas concentration in soil and groundwater were monitored by the collector method and nuclear track detection. The results indicate a true correlation between radon emanation rate and seismic activities in the study area (Tarakci et. al., 2013).

Knowledge about earthquakes has not been common before the first documentation in Ghana in 1615 (Amponsah, 2004). This made the understanding and knowledge about this disaster-causing hazard very scanty. Seismic data, stress level data, epicentral and seismic intensity, etc. were all unavailable. Some research works identify the cause of the seismicity to be unknown even after earlier recordings in the GAMA region, mostly distinguished by the coastal boundary faults around the Accra-Tema-Koforidua-Akosombo-Ho corridor of Southern Ghana (Amponsah, 2004). Others establish that the seismic regions of southern Ghana have been linked separately to tectonic faults and activities of the St. Paul’s and Romanche transform-fracture zone systems offshore in the Gulf of Guinea to onshore. It was concluded that the seismicity of southern Ghana is due to tectonic activities of the St. Paul's and Romanche transform-fracture systems (Kutu et. al., 2013).

Earthquakes as Disasters and their Magnitudes of Measurement

As a disaster, earthquakes acquired major attention in Ghana after the consideration of Low-Carbon-Powered Nuclear Power to boost the country's dwindling energy fortunes due to the disaster that may be associated with the siting of the reactor. This may be attributed to the long span in time of occurrence or the assumption that a major earthquake is not imminent since that of 1939 (Ennisson et. al., 2012). Recent works such as Attoh et. al., (2003), Attoh et. al., (2005), Amponsah et. al., (2009) and Kutu et. al., (2013) have emphasized that the areas having an underlay of unconsolidated sediments experience the greatest shaking (Amponsah et. al., 2009; Attoh et. al., 2003; Attoh et. al., 2005; Kutu et. al., 2013).

As observed in India (peninsula); in many compressional settings, faults have a tendency to grow into splays or blind thrusts and do not usually reach the surface. In such a situation the rupture that gets to the surface then develops geometries that are usually complex. Coupled with earlier scanty knowledge about earthquakes, the first documentation in 1615 in Ghana did not make much impact in terms of research.

After the introduction of the concept of earthquake magnitude by Charles F. Richter, earthquake data analyses became easier. The first unit introduced was the local magnitude, (M_{L}) which was followed by the body wave magnitude, (M_b), the surface-wave magnitude, (M_s) and then the moment magnitude (M_w). The moment magnitude veered from measuring seismogram peaks, capitalizing on the seismic moment, (M_o) of the events. Earthquake data relation to stress level was developed in 1942 by Guttenberg B. and Richter C. F. (Amponsah, 2002). By developing a relationship between the frequency of earthquakes and the overall number that occurs within given periods, the Guttenberg-Richter relation, as it would later be known, explains how the monitoring of earthquakes can help in disaster mitigation (Amponsah, 2002; Kutu et. al., 2013).

Geological Setting of Greater Accra Metropolitan Area

The instability of the fault-bounded basin filled with Jurassic to Tertiary sediments located in the continental shelf area of Accra is clearly demonstrated by the five distinct tectono-geological units of South Eastern Ghana. It is clear from seismic data that GAMA is geologically and seismically unstable, with strong subsidence dating back to the Jurassic period and resulting in downthrows of at least 5500 m of the offshore basin in relation to the continent (Amponsah, 2002).

History of Earthquakes in Ghana

Historically, earthquakes in Ghana and the subregion date back to a first record in 1615 with no identifiable magnitude measured. However, with a magnitude of 5.7, the 1636 earthquake had more damaging effect (Junner, 1941). Following the collapse of the Portuguese mines some of the miners were buried alive. The 1862 earthquake in Accra recorded a magnitude that affected areas like Usher fort, James fort and Christiansborg castle. That earthquake rendered the forts and castle uninhabitable and went as far as Togo. The 1939 earthquake, stated to have occurred 77 years after that of 1862 with intensity of IX, injured 133 people; the worse incident/disaster in Ghana's history of earthquakes (Doku et. al., 2014). The magnitude 6.5 earthquake, extensively analyzed, was recorded to have killed 17 people (Amponsah et. al., 2012; Junner, 1941).

In recent times GAMA has recorded frequent seismic activities but it is very easy to project this as a sign of impending major earthquake (Kutu et. al., 2013; Opoku, 2012).

After a 2013, re-assessment and re-interpretation of the 1939 earthquake, researchers came to a conclusion that the epicenter of the earthquake was not Nyanyano. The intensity was reestimated to a minimum of IX and a maximum of X. Towns of isoseismal intensity IX were identified to be Nyanyanor, Aplaku, Fete Amanfro, Tetegbu, Tokuse and Sakumono Lagoon. The earthquake was estimated to be caused by a shallow-depth northeast trending fault that propagated heavily along the Accra boundary faults. According to the findings, the earthquake was clearly a shallow-focus tectonic reactivated northeast trending strike-slip fault with sinistral sub vertical shear deformation within the Accra-Fete-Weija triangle of the Akwapim main block of the Accra region (Kutu et. al., 2013).

At the time of this work, no major earthquake of repeated magnitude of 6.5 had occurred; 80 years after that of 1939.

This natural crustal rapture that has helped to keep the earth in its spheroidal-structured geoid and acted as a stabilization phenomenon would continue till the earth loses its internal tectonic energy finally and totally. The invincibility of the event (interception of the major cycle by that of 1986, i.e., 1862-1906, gap of 34 years and that of 1939, i.e. 1906-1939, a gap of 33 years) is worth further questions and investigations.

The current publishing of events by the Ghana Geological Survey Authority (GGSA) on the Incorporated Research Institutions for Seismology, IRIS, website is worth commending. However, due to the current population and land size of GAMA, a comprehensive, unified and harmonized catalogue of daily events is necessary for easy future research. The impact of earthquakes on Haiti, Japan, United States of America, USA, Turkey, Ghana etc. cannot be overlooked. Ghana in particular has not been able to stick to effectively applying modern-science-engineering principles to develop the built environment against hazards like the USA (Allottey et. al., 2010; Kossobokov, 2005).

Over the past 400 years in the seismic history of Ghana, many advancements have been made in improving on the knowledge and technical base of seismology.

Indeed, it is very important to look at four hundred years of seismic activity monitoring in Ghana. Efficient and effective land use, planning, building code revision, formulation of policy, and the designation and operation of clear guidelines for the establishment of critical national infrastructure like overhead transportation systems, nuclear power plants, interchanges, bridges, shopping centers, dams, rail lines and so on would be possible only if we had enough seismic data that had been properly processed and interpreted. It has been observed that the hazard profile of Accra includes earthquakes, perennial flooding, Fire, coastal erosion, disease, air pollution and environmental degradation (CASA ASSOCIATI, 2012).

One cannot also easily generate isoseismal maps, epicentral intensity maps and seismic telegrams if we do not have a good record of processed events. Hazard maps can be easily generated since Peak Ground Acceleration (PGA) can be determined. Ghana’s Nuclear Power Institute, established in 2015 to help bring a permanent end to the country’s perennial power problem needs this information to be effective. Just like observatories in the world, Ghana is gradually developing disaster mitigation strategies that would aid in reducing the impact of future earthquakes. These research works are also helping the country to plan post-earthquake reconstruction programs to enhance clear policy direction for disaster victims. As for the need for sensitization of the masses about seismic disasters, it cannot be overemphasized. Active faults must be mapped out, but only by having seismic data. Currently, accelerometers (strong-motion based) have been installed on the Owabi, Barekese and Bui dams. Also, quarry sensor equipment installed on quarry and mining sites across the country are assisting in monitoring the country's man-made seismic hazard levels (Amponsah, 2004). The Comprehensive Nuclear Test Ban Treaty Organization (CTBTO) and the Ghana Atomic Energy Commission (GAEC) have been working together for eleven years (since 2010) to establish the National Data Centre (NDC), which also has access to seismic data from the International Data Centre. In and around the Accra Metropolis, more than local magnitude 4.0 earthquakes have been recorded (Amponsah, 2004; Amponsah et. al., 2012). Earthquake data has been useful in petrochemical exploration, understanding of local subsurface mechanisms, and nuclear test monitoring (Judson & Kauffman, 1990).

Earthquakes can take many different forms, but the majority of those that occur near intraplates are concentrated along pre-existing zones of weakness (such as fault zones, suture zones, fracture zones, failed drifts, and other tectonic boundaries) (Sykes, 1978). Fracture zones in continents that predate the formation of surrounding oceans tend to form seaward of major tectonic boundaries. Could the abundance of pre-existing zones of weakness southerly in trend be clear indications of a possible tsunami at the continental margins of Ghana? The observations of more and more earth tremors and earthquakes in recent times are also indicative of a gradual development of the major faults in GAMA. It is therefore important to look out for recent records of seismicity in and around southern Ghana (Amponsah, 2004).

In the absence of powerful tools for seismic hazard assessment or seismic risk analysis, source free Probabilistic Seismic Hazard Analysis (PSHA) procedures are usually employed to accommodate the incompleteness of the seismic catalogue (such as in the case of the 1615 earthquake of Ghana) with the non-requirement of a specification of seismic sources. Defining potential seismic source zones (usually associated with active geological and tectonic features like faults) and determining seismic parameters for each source zone in terms of seismic characteristics, average rate of occurrence, level of completeness of catalogue etc., have been the determinants of a successful work (Ahulu et. al., 2018).

Under tectonic stress and strain, fluids trapped and segregated in pores, tissues, and fractures of deep geological formations can become mobile and migrate into shallow horizons or to the surface, eventually causing earthquakes. The amount of strain applied to rocks determines the opening of cavities and the amount of fluid released. The components of fluid released give a clue of chemical and isotopic anomalies; which most of the time give a prediction of an impending earthquake or tremor. Prominent among these precursors are Carbon (IV) oxide, CO_2, and Rn-222. They are quite promising. About 70% of earthquakes have been observed to be preceded by radon anomalies detectable in soil/air/groundwater indicating that the variation in concentration of radon is an indicator (Noguchi & Wakita, 1977; Brandes, 1988; Smith et. al., 2009).

Isotopic and geochemical precursors can be monitored along with other hydrological and geophysical parameters by searching, selecting, and using the most informative ones like CO_2 and Rn-222. The behaviour of the precursor can then be analysed; theories and models can then be formulated to establish a trend to be followed. According to observational data from earthquake catalogues, the magnitude of seismic events increases with distance of recording seismic event precursors. In addition, larger signal amplitudes of earthquakes mean earlier appearance of precursor signals. In such proceedings, care has been taken in processing the grounding alert in an on-line regime, outgassing device has been prevented from corrosion and precipitation of $CaCO_3$, organic and suspended particles (Brandes, 1988; Smith et. al., 2009).

Variations of meteorological conditions such as temperature, pressure, air humidity etc. are usually corrected from observation data. In this case, the monitoring system provides discrete or continuous regime of measurements with the required accuracy (Smith et. al., 2009, Wakita et. al., 1988). Small changes occurring in the local stress intensity are thought to be the cause of observed radon anomalies. The structural inhomogeneity of geological bodies has resulted in several stress concentration centers where Rn molecules' internal free energies can reach a potential barrier to be transferred from solid matrix to pore fluids (Noguchi & Wakita, 1977; Brandes, 1988; Smith et. al., 2009, Wakita et. al., 1988).

The majority of radon anomalies are found far from the epicenter. The initial stage of radon movement from rock matrix minerals in a strained state into pore fluids is commonly assumed to have thermo-molecular activation character. The activation character follows the kinetic laws in general (Sigaran-Loria et. al., 2007).

Indeed, earthquakes are major threats to humanity, and scientists and engineers face a significant challenge in preventing their catastrophic consequences (Doku et. al., 2014). Most of our activities as humans are reliant on seismic, tectonic, and geodynamic conditions and events. The Track Etch method can easily be used to unravel these. It is also known that large earthquakes can cause or trigger landslides (Sigaran-Loria et. al., 2007).

As elaborated by Ioane and Stanciu in 2017, we can safely say plate tectonics, volcanic activity, and meteorological phenomena, planetary influences (like tides of the moon) and earth’s core dynamic processes influence seismic activities (Ioane & Stanciu, 2017). We see clearly that pore water controls seismic stress release. Pore water therefore is worth recognizing as an earthquake triggering factor. What role then does precipitation play alongside pore radon emanation in resulting earthquakes and earth tremors? The answer lies in investigating and putting up a hypothesis for dilation and radon gas emanation at different altitudes with respect to different geological formations. It is a well-established fact that GAMA's microseismic events are usually close to the Akuapem fault zone and the coastal boundary faults especially at their intersections. From a hypothesis for dilation and radon gas emanation, one can easily reconcile the quantum of events around GAEC and McCarthy Hill based on their geology, mostly sand and clay and mostly faulty rocks respectively. Hence, the earthquake zoning developed in the physics department of the National Nuclear Research Institute (NNRI) of GAEC. Aside these hypotheses, the pressure that comes alongside rainfall and how the rainfall diffuses into the ground are worth investigating (Amponsah et. al., 2009).

National Geographic News reported on December 15, 2011 that high precipitation can cause a heavy earthquake. After digging through nearly 50 years of earthquake and weather records for Taiwan, Shimon Wdowinski of the University of Miami, Florida, first noticed a link between storm and earthquake in 2012. (An Island that experiences a lot of severe rainstorms and earthquake). It is observed that there's less stress on the underlying rocks after very high precipitation and it is easier for faults to move (Lovett, 2011).

It is worth noting that the main driver that causes earthquakes is plate tectonics. In the Vrancea Zone, Romania, many attempts have been made to scientifically link seismicity to a variety of precursors in seismically active areas. Attempts were also made to identify phenomena such as active tectonics or Sun-Earth-Moon gravitational interactions that could end up triggering seismic events, particularly those at a high altitude. The main cause of increased seismicity in spring and autumn was determined to be caused by heavy precipitation and/or snow melting in these areas. Water infiltrates deeper into the earth, increasing activity along active faults. During the summer, the precipitation regime is weaker. Water is mostly represented by snow during the winter, and its deep infiltration is usually prevented by frost (Ioane & Stanciu, 2017).

Delimitation of Study Area

As a fundamental methodology in seismotectonic investigations, delimitation is necessary if we are to assess GAMA's seismicity in order to gain a complete understanding of it. To gain a clear understanding of GAMA's seismicity, the immediate surroundings must be compared to other geologically similar areas such as Togo, Burkina Faso, and Cote d'Ivoire. Earthquakes have no boundaries in terms of location. The inclusion of these locations would also aid in the collection of sufficient seismic, meteorological, and geochemical data for the study area's stress estimation. The b-values were calculated by including data from the sub-region in Mavonga and Durrheim's (2009) Probabilistic Seismic Hazard Assessment for the Democratic Republic of Congo and Surrounding Areas (Mavonga & Durrheim, 2009; Doku et. al., 2014). The same principles were applied to the selection of precipitation data as well as historical and current radon data. It has become increasingly difficult to carry out this work based on limited data, and in analysing seismic activities in Ghana; seismic data from Ghana's immediate neighbours were also taken into account (Amponsah, 2004; Doku et. al., 2014). Outside of GAMA, radon detectors were installed, and seismic data were collected to cover Ghana's immediate neighbours.

Statement of the Problem

From as far back as the 17th century, the Gold Coast (Present day Ghana) has experienced a lot of damages from earthquakes, some leading to the loss of life and property (Amponsah, 2004). A lot of research has been done using seismic data and geology to create hazard maps (Doku et. al., 2014). Delineating fault zones, however, cannot be whole in the absence of other ways of finding out the exact stress level of GAMA.

Doku et. al., 2014 recommended further works to establish a b-value for southern Ghana and reconcile it with the geology of the area. Unification of available catalogues is very important if a true b-value must be evaluated. The failure of earlier works to harmonize all the earthquake catalogues and models to estimate and predict the stress level of GAMA, seismologically, meteorologically and geochemically is of high national concern. Since 1615, when the first earthquake was recorded in Ghana, only one b-value has been calculated. There is no work in unification of geochemical precursor results, b-value and meteorological pointers to seismicity. The identification of the fact that the geology of GAMA supports underground percolation of rainwater assisting in the diffusion of water to the lower layer of the upper crust is not enough. The recent seismic activity in southern Ghana has intensified the urgency for investigating the causes of the earthquake activities. The previous and current seismicity in southern Ghana can be explained geologically. The majority of discussions about Ghana's seismicity have centered on earthquakes in the Accra-Ho seismic region in southeastern Ghana; these discussions appear to have been generalized for the entire country, implying that the seismicity of the entire southern Ghana has a common cause whilst this is not the case. This broad generalization that simplifies the nature and comprehension of the Ghanaian phenomenon must be assessed (Kutu, 2013).

Justification

Accra, according to recent research in West Africa, is the region's most seismically active city (Amponsah et. al., 2012; Doku et. al., 2014). Large oceanic transform faults, such as suture zones near Accra, have a major pre-existing tectonic boundary landward, according to world seismicity updates, indicating the possibility of a large shock in the future (Ambraseys & Adams, 1986; Sykes, 1978). Earthquakes that occur around intraplate areas do not have a random distribution but rather are well associated with faults and other zones of weakness that can be identified with the last major orogeny of a region (Sykes, 1978). Such is the clear case of GAMA. A good hazard map is impossible without exhausting various approaches of detailed seismic hazard assessment (Allotey et al, 2010). The right framework for seismic hazard assessment is to develop thematic mapping with identification and characterization of seismically active and inactive zones. A blend of meteorological evaluation and geochemical precursors by monitoring precipitation, and pressure from precipitation and diffusion of radon gases are well established and tested rudiments. Nothing can be left to chance because the extreme catastrophic nature of earthquakes has been observed and known for centuries due to the devastation accompanying many of them.

Fractures and joints serve as the pumping systems for groundwater flow (Asumadu-Sakyi et. al., 2012), clear evidence of relative movements due to friction and rigidity of the rocks. Constant investigation of these fault zones so as to observe the relationships; taking into consideration geophysical, geological, meteorological, geochemical and physical data. These can give an improved program that might give a precursor location and time of impending events.

Just like seismicity and epicentral intensity maps, isoseismal maps are important as they reveal the possible degree of damage that could occur should an earthquake of $6\ M_w$ and above re-occur. Previous researches did not investigate the use of b-value, meteorological and geochemical precursors in evaluating the stress level and hazard in GAMA.

It is however important to note that the relationship between meteorology and seismicity, and geochemistry of the earth and seismicity are complex and not fully understood. While there is some evidence to suggest that these factors can influence one another, the impact is likely not easily noticeable compared to other factors that influence earthquakes, such as tectonic plate movements and the underlying geology of an area (Zhang & Chen, 2015).

Research into the relationship between earthquakes and precipitation (and other meteorological factors) can be justifiable for a number of reasons. Understanding the factors that contribute to the likelihood of earthquakes occurring can help scientists and policymakers develop strategies for mitigating the risks and impacts of earthquakes, such as through the development of early warning systems or improved building codes. Additionally, studying the relationship between earthquakes and meteorological factors can help scientists better understand the complex processes that govern the Earth's crust and atmosphere, which can lead to a greater understanding of the Earth's overall systems and processes (Pacheco & Tormey, 1997; Mavroeidis & Papazachos, 2006).

Overall, while the relationship between earthquakes and meteorological factors is complex and not fully understood, there is value in studying this relationship in order to better understand earthquakes and their impacts, and to develop strategies for mitigating their risks and impacts.

On the other hand, radon is known as a naturally occurring radioactive gas that is produced by the breakdown of uranium in the Earth's crust. It is the second leading cause of lung cancer, and can be harmful to human health if it accumulates in buildings or other enclosed spaces (WHO, 2009; WHO, 2013; WHO, 2020). There is some evidence to suggest that earthquakes can release radon gas from the Earth's crust, either through the rupture of rock formations or the alteration of underground gas pathways. As a result, researching the relationship between earthquakes and radon gas emissions can be justifiable for a number of reasons (Sun & Helmberger, 2001; Zhang & Chen, 2015).

Understanding the potential for earthquakes to release radon gas can help policymakers and health officials develop strategies for mitigating the risks to human health (WHO, 2009; WHO, 2013; WHO, 2020). This might include monitoring radon levels in buildings after earthquakes or developing guidelines for safe levels of radon exposure. Studying the relationship between earthquakes and radon gas emissions can help scientists better understand the processes that govern the Earth's crust and the movement of gases within it. This can provide insights into the overall behavior of the Earth's systems and help us better predict and understand earthquakes and other geologic phenomena (Sun & Helmberger, 2001; Zhang & Chen, 2015).

Researching the relationship between earthquakes and radon gas emissions can also help scientists understand the potential health impacts of earthquakes and develop strategies for mitigating those risks. For example, understanding the likelihood and magnitude of radon gas releases after earthquakes could inform the development of guidelines for evacuating or sheltering in place after an earthquake (Zhang & Chen, 2015).

Overall, while the relationship between earthquakes and radon gas emissions is not fully understood, there is value in studying this relationship in order to better understand earthquakes and their impacts on human health and the environment.

Objectives

Main Objective

To assess the seismological, meteorological and geochemical effect of earthquake hazard in Ghana.

Specific Objectives

1. To investigate and generate an improved, complete and standardised earthquake catalogue for Ghana by seismological investigation from 1615 to 2018.
2. To investigate the current seismological, meteorological and geochemical stress level of the Greater Accra Metropolitan Area.
3. To come up with current seismicity, epicentral-intensity and isoseismal maps for the subregion, Ghana and GAMA from the earthquake catalogue.

4. To establish a relationship between seismicity and precipitation (meteorology), and seismicity and radon emanation (geochemistry) in the GAMA.

Chapter Summary

To be able to define potential seismic source zones (usually associated with active geological and tectonic features like faults) and determine seismic parameters for each source zone in terms of seismic characteristics average rate of occurrence, the level of completeness of catalogue etc. have been the determinants of a successful work.

Under tectonic stress and strain, fluids trapped and segregated in pores, tissues, and fractures of deep geological formations can become mobile and migrate into shallow horizons or to the surface, eventually causing earthquakes. It is necessary to investigate and establish the relationship between these occurrences and their impact on the GAMA region's seismotectonic history. This will be done by conducting a seismological, meteorological and geochemical invesgtigation to assess the degree of hazard in the study area and also find out possible ways of mitigating them.

CHAPTER TWO

LITERATURE REVIEW

Introduction: Previous works related to the study are reviewed here.

Seismological Works

A comprehensive examination and report on the earthquakes in Ghana, as well as an in-depth examination of the earthquake in 1939 (6.5 Mw) for the first time in Ghana's seismic history in 1941 (Junner, 1941) and a geophysical investigation conducted into the seismic history of the Weija area established that the area is seismically active. Essel (1997) asserts that microseismic studies in southern Ghana indicated that the seismicity is associated with active faulting between the eastwest trending Coastal boundary fault and a northeast-southwest trending Akwapim fault zone, defined by a number of active faults (Essel, 1997). A geophysical study by Essel (1997) indicated that the seismic activity is related to deep-seated fault. Rajendran (2000) also observes that fault developments occur as splays or blind thrusts which may not reach the surface in many compression settings (Rajendran, 2000). He further concludes that this is based on the use of geological data to study earthquakes. It was discovered that surface-level ruptures tend to develop complex geometries. According to Sykes (1978), a lot of earthquakes are usually temporally and/or spatially connected with zones of weakness, which can be established from an earthquake hazard standpoint (Sykes, 1978). The Cameroon line and the Ngaourandere fault zone are also at the Congo's border with a Pan-African deformation belt that runs as far west as Accra (Sykes, 1978; Attoh et. al., 2003). Bacon and Quaah (1981) identified that majority of the epicenters south of Weija are related to the reactivation of an ancient thrust zone that has been resuscitated (Bacon & Quaah, 1981). Most earthquakes in Ghana occur at the intersection of two major fault systems in the western part of Accra which are the Akwapim fault zone and the Coastal boundary fault (Amponsah, 2004).

Evidently, in Ghana, the occurrence of earthquakes is concentrated near the coastal boundary fault and the Akwapim fault intersection. Ghana's seismic activity is concentrated in the southeast, at the intersection of two major active faults (Amponsah, 2002).

On the Romanche transform boundary offshore, the seismic stratigraphic record of uplift and transpression tectonic inversion, on the other hand, may be implicated in neotectonic activity around the Pan-African Structures (Attoh et al., 2003). Furthermore, near the south end of the Pan-African Front (PF) and the Coastal Boundary Fault (CBF) intersection, Attoh et. al., (2005) sought to establish increasing neotectonic activity (Attoh et. al., 2005).

According to the GGSA (Amponsah et. al., 2012)., the Seismology Division is responsible for the daily monitoring of seismic (earthquake) events in the country. Currently, the monitoring is done with the Ghana Digital Seismic Network (GDSN) installed in October 2012. Occasionally, geohazard mapping and risk assessment (seismic micro-zonation) projects are carried out in geo-hazard/earthquake prone areas, especially GAMA (Amponsah et. al., 2012).

Ground motion estimates use the seismic (earthquake monitoring) data to create a new National Seismic Hazard map. This will be used as the foundation for long-term socio-economic geo-hazard mitigation through effective and efficient land use planning, and by formulation of a reviewed building code based on technical considerations and Ghana's economic conditions, designing standards for critical or lifeline structures such as all types of dams, bridges, nuclear power plants and overhead transportation systems have been developed. Others include, disaster mitigation strategies being developed to lessen the impact of future earthquakes. To avoid a repeat of the failed reconstruction program, post-earthquake reconstruction is needed and also insurance with clear definition policies to mitigate the effects of earthquakes is also important, exploration and research into the earth's internal composition (e.g. kimberlite pipes location in Ghana) and to contribute towards the global seismological research especially within the West African sub region can also not be avoided (Attoh et. al., 2003; Attoh et. al., 2005).

Attoh et. al. (2005) also stated that periodic geo-hazard and risk assessment is required for seismic micro-zonation, which involves determination of the earthquake hazard of varied ground conditions throughout a city or metropolitan area. It is noted that the resulting seismic micro-zonation map can be used by urban planners as a valuable additional resource for incorporation of earthquake safety factors into their routine land-use planning decisions. On the map, you can identify potential liquefaction, potential slope collapses, potential ground motion amplification and landslides or rock falls (Attoh et. al., 2005).

Furthermore, a research work by Talwani concluded that major earthquakes in continental interiors have inflicted disproportionate damage despite the fact that they are significantly less common than those along plate boundaries. He argues that the nature of seismicity in continental interiors is not clearly understood as compared to those at plate boundaries (Talwani, 1998).

It is observed that in such areas, stress conditions, nature of fault zones associated, geology and rheological properties of the medium are key factors that can influence the seismicity (Talwani, 1998).

The epicenters of earthquakes are related to the active parts of the faults, though it is impossible to assign them to individual faults or fault sections due to numerous sources of inaccuracies. Amponsah et al. (2009) used GAMA seismic ground motion modelling using deterministic computation for land use planning and disaster mitigation. The paper combined the modal summation and finite difference methods to create a hybrid method. The calculated Peak Ground Accelerations (PGAs) ranged from 0.14 g to 0.57 g. The areas underlain by unconsolidated sediments were found to have the most shaking (Amponsah et. al., 2009). Mavonga and Durrheim (2009) compiled all available catalogues for the Democratic Republic of Congo and surrounding areas from 1910 to 2008 in the region 14 ° S to 6 ° N and 10 ° E to 32 ° E. The b-values for three key active areas, the Upemba-Moero Rift, Congo Basin, and Western Rift, were calculated and found to be 0.813, 1.020, and 0.773, respectively (Mavonga & Durrheim, 2009).

Meteorological Works

Liritzis and Petropoulos (1992) analyzed the data of annual rainfall of Athens for 119 years (i.e., 1872–1991) which they compared to the occurrence of large earthquakes of moment magnitudes greater than 6 along the fault and thrust systems of the region in a preliminary study of the relationship between precipitation and large earthquakes (Liritzis & Petropoulos, 1992). The paper stated that planetary influences (e.g. Moon tides), plate tectonics, meteorological phenomena, earth's core dynamic processes and volcanic activity are all common causes of earthquakes. The role of pore water in controlling seismic stress released has been currently identified to be under researched extensively. In earthquake prediction, pore water and precipitation have been identified as key triggering factors (Liritzis & Petropoulos, 1992). Many shallow earthquakes have been identified to be preceded by the gradual opening of cracks and pores in highly stressed rocks, causing the rock to dilate (Dilation Hypothesis). Dilation hardening accumulates dilation. Only after the pores have been filled with water, which reduces friction across a fault and allows it to move, does an earthquake occur (Liritzis & Petropoulos, 1992).

They paper was however not very absolute about deep focus earthquakes being explained clearly by dilation. As a possible triggering mechanism in earthquake release, the effect of rainfall pressure, as well as its diffusion, must be considered (Liritzis & Petropoulos, 1992; Lovett, 2011). Drakopoulos and Makropoulos (1983) examined the Greece territory with a close seismic history to that of Ghana. They used rainfall data from the Climatological Bulletin of the National Observatory of Athens as well as unpublished data from the Institute of Meteorology of the National Observatory of Athens in their research, and they relied on earlier catalogues (Drakopoulos & Makropoulos, 1983). The choice of moment magnitude greater than 6 thresholds is taken purely for hazardous reasons and the key reasons for choice of magnitude threshold included rainfall patterns derived from the tabular data and patterns compared to years prior to large earthquakes in order to see if there was any valid correlation between earthquake occurrence and rainfall distribution. Annual variation of precipitation was plotted. Thus, yearly average against the years in perspective. It was established that the extent of landslide is related to the magnitude and nature of the event, and the sizes of failures are dependent on the relation between the slope aspect and the ground shaking (Drakopoulos & Makropoulos, 1983).

Ayetey and Andoh (1988) investigated the line of boundary between the African Craton's belt and the Pan African mobile belt, both of which are very close to Accra, in their Earthquake Site Response Study of Accra, Ghana. Many development projects have been cited in areas with a high risk of earthquakes (Ayetey & Andoh, 1988).

Accra's geology is dominated by the Dahomeyan series, which are metamorphosed Precambrian sediments that are now mostly gneiss, hard, foliated, and folded. It is possible that a trust fault contact exists between the Dahomeyan and Togo Formations, causing the Togo to slide over the older Dahomeyan. The Devonian shades and interbedded sandstones form the foundation of Accra, with the sandstones becoming massive at the base (Ayetey & Andoh, 1988).

Most of the hypotheses for an earthquake's generic cause are focused on the sudden release of strain energy caused by a fracture or slip along an existing fault. A sudden strain energy change caused by density metastability of a confined mass of rock can also cause earthquakes (Ayetey & Andoh, 1988).

With the exception of the areas in Accra traversed by isoseismals VI and above, several other areas have groundwater relationships, soil cover, surface topography and bedrock topography that when combined with the area's numerous faults, could make them vulnerable to damage during earthquakes. Accra is mostly built on clays and sands, according to the study, and groundwater conditions are crucial to earthquake site response characteristics. Additionally, foundations in sands are associated with much more challenges. Shale type foundations and sand-based reinforced concrete structures are recommended for building design and construction in Accra (Ayetey & Andoh, 1988).

The meteorological triggering of earthquake swarms at Mt. Hochstaufen, SE-Germany was studied. It was observed that a growing body of evidence suggests that fluids are intimately linked to a variety of faulting processes. Yet, the particular mechanisms through which fluids and associated parameters influence the stress regime and thus the seismicity of a particular area are not well understood. The study was carried out to observe the spatio-temporal behavior of earthquakes, fluid-related parameters (groundwater levels) and meteorological observables (precipitation). They found significant correlation of seismicity with rainfall and groundwater level increase, and estimate an average hydraulic diffusivity (Kraft et. al., 2006).

Geochemical Works

By 2001, the majority of radon research in the Lake Bosomtwi area had shifted to geophysics, which relied on the changing concentrations of radon gas emitted from the soil. Prior to this, in 1967, Union Cabide, a petroleum exploration company, conducted an extensive seismological survey across a section of the continental shelf extending from Accra's southern outskirts to the Volta River. The survey's findings revealed that the area was seismically active.

The presence of radon gas in the soil can be a sign of impending seismic activity. Microfracturing prior to major seismic events, according to the Increased Reactive Surface Area (IRSA) model, is responsible for precursory increases in radon gas concentrations (Furlan & Tommasino, 1993).

In 2015, H. Woith's research shows more than 100 publications reporting radon anomalies to precede earthquakes. The work records a clear apparent negative correlation between the number of reported anomalies and the published length of the time series. It is observed that 19% of all time series are longer than 5 years, characterized by a precursor rate of less than one precursor per year, with the extreme case being 1 anomaly in 18 years during monitoring of radiations and occurrence of events (Woith, 2015).

On the contrary however, precursor rates between 1 and more than 10 precursors per year stem from published time series shorter than 3 years and nearly 50% of the time series contain exactly one radon anomaly (independent of the length of the observation interval). It was concluded that generally, the number of anomalies is about 5 times higher at sites where radon is measured in soil air as compared to radon in groundwater. Also, significant radon anomalies exist, and therefore seismo-tectonically induced radon anomalies probably exist (Cartlidge, 2012; Woith, 2015). Anomalies in radon emissions can therefore serve as precursors of earthquakes (Ghosh et. al., 2009; Miklavčić et. al., 2008).

Radon and Health

Radon is a naturally occurring radioactive gas that is produced by the breakdown of uranium in the Earth's crust. It is the second leading cause of lung cancer, and can be harmful to human health if it accumulates in buildings or other enclosed spaces (Nsiah-Akoto, 2010).

Linde and Dworkin (2002) used numerical models to investigate the mechanisms by which earthquakes can release radon gas from the Earth's crust, and found that the release of radon gas is likely to be more significant in areas with high levels of uranium in the crust (Linde & Dworkin, 2002). According to Smith et. al., (2008) a review of radon emissions from fault zones discussed the evidence of radon emanating from fault zones (areas of the Earth's crust where earthquakes occur) and the potential health risks associated with radon exposure. They concluded that high radon concentrations can be found in fault zones and this makes the habitations of those places dangerous (Smith et. al., 2008).

Following earthquakes in Japan, Ohtani et. al., (2000) studied radon levels in air and groundwater and found that earthquakes can cause significant increases in radon levels in the air and groundwater (Ohtani et. al., 2000). Lim et. al., (2012) measured radon levels in soil gas following earthquakes in South Korea, and found that earthquakes can cause significant increases in radon levels in the soil gas (Lim et. al., 2012).

Nucciotti et. al., (2015) assessed the radon risk after earthquakes in the Marche region (Central Italy). They measured radon levels in indoor air and soil gas following earthquakes in Italy, and found that earthquakes can cause significant increases in radon levels in indoor air and soil gas. The study also discussed the potential health risks associated with radon exposure after earthquakes (Nucciotti et. al., 2015).

The b-Value and Seismicity

The b-value, also known as the "b-parameter" or "b-coefficient," is a measure of the relative frequency of small earthquakes to large ones within a particular geology. It is commonly used in the field of seismology to assess the likelihood of future earthquakes and to understand the underlying geology of a region (Knopoff, 1964).

Sometimes known as the Gutenberg-Richter b-value, it can be applied to measure the stress of the study area. It was used to estimate the likelihood of future earthquakes in the area based on the size and frequency of past earthquakes generated in the catalogue (Knopoff, 1964; Kanamori & Koyama, 1973).

The b-value represents the nature of the occurrence of earthquakes. A typical b-value characterizes the state of stress in the crust. Values less than or equal to 1 indicate distributions of earthquakes with locations around the upper crust. They also show high strain where the locations can be identified as fault, fracture, shear or tectonic zones of weekness (Bilim, 2019).

In terms of time, space and magnitude, earthquakes are not evenly distributed. Scale invariability exists in the distribution of earthquake magnitudes, which follows a power law known as the magnitude-frequency relation. The relation shows deviation from linearity resulting from the saturation of magnitude scales and the challenges with the measurement of magnitudes. The available catalogues sometimes have rarer large magnitudes and are too short (Kulhanek, 2005). While Kagan (19991a) and Kagan (19991b) believe that b-values rarely change (Kagan, 19991a; Kagan, 19991b), others, such as Felzer (2006) is of the opinion that b-values vary significantly in space and time (Felzer, 2006). As compared to the linear least square estimation of the b-values, the maximum likelihood estimation (MLE) rides on the back of two key assumptions to improve the mathematical model that calculates the b-value. These include, data being independently distributed and data being identically distributed.

Epps (2019) proffers that the MLE calculations follow the Normal Gaussian Distribution and the difficulty now certainly lies in where along the x-axis the peak appears as indicated in Fig.2.1 (Epps, 2019).

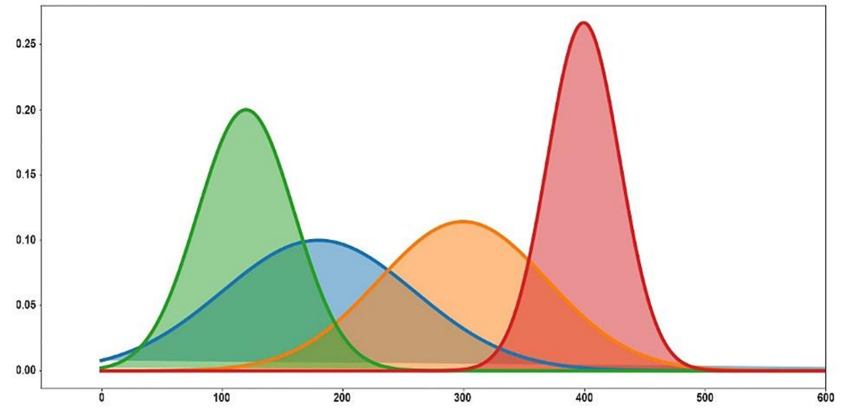

Figure 2.1: Normal Gaussian Distribution (Epps, 2019)

Assuming we have some continuous data and we assume that it is normally distributed. By assuming normality, we simply assume the shape of our data distribution to conform to the popular Gaussian bell curve. Here, we do not know where along the x-axis the peak occurs. Since we are dealing with a continuous probability distribution, the probability of observing any set of continuous variables is equal to zero. Conceptually, this makes sense because we can come up with an infinite number of possible variables in the continuous domain, and dividing any given observation by infinity will always lead to a zero probability, regardless of what the observation is. The curve therefore looks at the probability *density* rather than probability. The probability density in the continuous domain is analogous to probability in the discrete domain. Therefore, probability density can be used in this maximization problem (the maximum likelihook estimation) (Epps, 2019).

Smaller earthquakes are more common as compared to large earthquakes (M_w>7.2), according to instrumental data. Also, b-value is more accurately estimated from smaller earthquakes using small-time sampling, but not for large ones. Earthquake series with low and high b-values can be caused by high and low stress, respectively. This is a measurement of stress and structural anomalies occurring in the upper mantle and/or crust (subduction) (Kulhanek, 2005). When this observation is used, Wiemer et. al., (1998) claim that there is a possibility of earthquake identification and predictions of active magma volumes (Wiemer et. al., 1998).

MLE was applied to determine event magnitudes based on a statistical model assumption that includes the additional information that the event magnitudes at non-detecting stations must be below a certain threshold value. When applied properly, the MLE has a potential to yield significant improvement in network estimates compared to the conventional averaging technique (Ringdal, 1976).

Geologic Structures and Seismicity

The Greater Accra Metropolitan Area is a low-lying area. There are prominent ranges of hills running north-east from the coast in Nyanyano, the epicenter of the 1939 earthquake, rising to more than 600 ft (183 m) above sea level. In fact, the terrain is undulating (Junner, 1941).

Depending on the underlying rocks, earthquakes have a wide range of effects on buildings and other structures. The five distinct tectono-geological units of Ghana are interspersed with GAMA's tectono-geological units. These are The Akwapim Togo belt, The paleoproterozoic complex of the West African Craton (WAC), The Pan-African province of neoproterozoic metamorphic age, The Voltaian basin of the WAC and several small sedimentary basins of Post-African age (Attoh et al., 2003; Attoh et. al., 2005).

Three distinct tectonic elements define the tectonic setup of GAMA and its offshore area: the coastal area near-coast shelf fault which has the coastal boundary fault as its most prominent feature, the Akwapim fault zone and the Romanche fracture zone (Attoh et. al., 2005).

Tectonic inversion and tectonic reactivation along the seismic Pan-African fracture zone, according to Attoh et al. (2005), could be part of neotectonic activity along the Pan-African structures (Attoh et. al., 2005).

Attoh et. al., (2005) recommend a throrough investigation of the relationship between the Pan-African Structures and seismic activity along the coast of Ghana in order to fully comprehend the phenomena of intraplate seismicity in the study area (Attoh et. al., 2005). Several events recorded on and off-shore GAMA demonstrate this. The seismic stratigraphy of the Ghana margin strongly shows that uplift-related sub-aerial erosion occurred after folding, not before, and that transpressional deformation likely contributed to uplift along the Cote d'Ivoire – Ghana Transform Margin (CIGTM) (Attoh et. al., 2003).

There has been a lot of seismic activity in some parts of Accra, such as Weija, where the Akwapimian rocks are fractured and faulted and contain bands of soft Phyllite.

Precipitation, Radon and Seismicity

Precipitation-earthquake relationship was established in Athens (Huang et. al., 1979). Periods when rainfall was below average, periods between the earthquake event and a preceding rainfall peak above average (premonitory) and duration of this premonitory peak were studied. The results revealed increased seasonal precipitation of above average for 1 and occasionally 2-3 years by a major earthquake. Also, a tentative relationship was obtained by applying correction test on the height premonitory precipitation peak and the time lag between either of them and the onset of the great earthquake. Prediction curves were plotted and preliminary findings point to a link between precipitation changes and the occurrence of a large earthquake in the Athens region. This means the longer the period for an unexpected major earthquake to occur, the higher the rainfall peak (Huang et. al., 1979; Liritzis & Petropoulos, 1992).

From Wang et al. (2006), it can be gleaned that a foreshock sequence was the most critical precursor, although other anomalies such as changes in groundwater level, colour and chemistry, geodetic deformation and unusual animal behaviour also had a role to play (Wang et. al., 2006).

Also, the relationship between radon anomalies and seismic activity in Tuzla fault Zone in Western Turkey was investigated (Tarakci et. al., 2013). They observed that seismic activity across the world required the investigation and development of new methods for predicting earthquakes. The methods used to observe variations of radon gas concentration in soil and groundwater were collector and nuclear track detection methods. A 0.28 BqL^{-1} to 11.01 BqL^{-1} collector for thermal waters with 1 yr 50 track cm^{-2} $week^{-1}$ to 750 track cm^{-2} $week^{-1}$ were recorded and the results indicate a true correlation between radon emanation rate and seismic activities in the area under investigation.

According to Tarakci et. al. (2013), predictions of seismic activities in the world are based on quantitative relations between seismic parameters such as earthquake magnitude, epicentral distance and geochemical anomalies occurring in subsurface gas and groundwater (Tarakci et. al., 2013).

Indeed, the emanation of radon has been associated with tectonic changes in the earth's crust, according to measurements of temporal variations in radon in soil and water, earthquakes are not followed by radon anomalies all the time, and also not every increment in radon levels are followed by earthquakes. Despite this, the radon approach has been used to predict earthquakes all around the world. The fact that six-valence Uranium is relatively easily soluble and is leached out of the rock by water, accounts for the high concentration of R_n in groundwater. The research identified fault zones of weakness in the study area and also took note of the fact that faults in the study area orient and re-orient in slip, earthquakes are environmental phenomena that affect population, local cultures, national infrastructure, economic and social activities and that changes in radon concentration in soil gas and groundwater vary greatly over time, have inconsistent features, and are difficult to interpret (Tarakci et. al., 2013).

In Punjab, India, RAD7 was used to measure radon levels in ground water and calculate the average yearly dose (Badhar et. al., 2010). In doing this, the authors published that radon radiations constitute an important part of the environment in which one survives. These radiations could be Primordial, Cosmic or Artificial. Radon is a radioactive noble gas that can be found in various levels almost everywhere. R_n-222 is the predominant one with half-life of 3.82 days and is a product of the decay of U-238 in rocks, soil and water by the emission of alpha-particles. Decayed radon is inhaled into lungs and energy released is capable of causing damage to the DNA in sensitive lung tissue and cause cancer.

For a month, water samples were collected from the study area's environs and analyzed using a solid state nuclear track detector. The detectors were removed and etched for 90 minutes in a 2.5M NaOH solution at 60°C. The density of the tracks was then counted using a 400 X magnification optical microscope (Badhar et. al., 2010).

The geological structure of the area, the depth of the water source, and climate differences could all play a role in radon concentration variation. In fact, the presence of radon gas in soil can signal the onset of a seismic event. According to Furlan and Tommasino, the Increased Reactive Surface Area (IRSA) model, microfracturing prior to major seismic events accounted for precursory increases in radon gas concentration (Furlan & Tommasino, 1993). Bella and Shiratoi (1990) proposed a hypothesis based on an experiment on hot water springs in Japan that a correlation may exist between radon gas content variations (Bella & Shiratoi, 1990). Researchers worked on radon gas measurements in the Tashkent hydrological basin fifteen years prior to an earthquake. Between 1961 and 1964, the level of radon gas increased steadily. It was finally discovered that an increase in radon gas concentration corresponded to an increase in seismic activity (Ulomov & Mavashev, 1967).

Allegri et. al., (1983) took water samples from an artesian well in Mentana (near Rome) and the Peschiera springs on a regular basis (near Rieti). From the beginning of June to the end of October, the researchers noticed a significant increase in radon gas concentration. This was preceded by a sharp decrease in the days preceding the November 23, 1980 Irpinia earthquake (Allegri et. al., 1983).

Daily variations of atmospheric Radon-content near the surface of the ground were observed in Tottori for one year, according to Okabe (1956), and the effect of wind direction, wind velocity, atmospheric pressure, atmospheric temperature, and rainfall on atmospheric radon contents was also investigated. The impact of local earthquakes in the Tottori area on the increase in atmospheric radon content was studied in depth, and a reasonable correlation was established (Okabe, 1956).

Seismicity of the Greater Accra Metropolitan Area

When one compares the epicenters of earthquakes recorded between 1900 and 1973, it is possible to conclude that the west coast of Africa has low seismicity (Singh et. al., 2009). GAMA, like other intraplate regions, has seen earthquakes of magnitude 2.5 and above as observed in parts of Scandinavia and Greenland (Gregersen, 2006). Earthquakes with an average focal depth of 20 kilometers have also been recorded in the East African Rift System (Doku et. al., 2014)

Table 2.1 gives a brief background into recent notable seismic activities in Ghana. It can be seen that as far back as 1636, earthquakes have been recorded in the study area.

Table 2.1: Seismicity of Ghana

Year	Magnitude (M_w)	Remarks
1636	5.7	Experienced in Axim. Buildings and underground workings of Portuguese mines collapsed.
1862	6.5	Accra was razed to the ground, and every structure was destroyed. The Osu Castle and Forts in Accra were rendered uninhabitable. The shocks were experienced in Togo, where the water level of the Mono River had dropped significantly below normal.
1906	5.0	Many structures in Accra, especially castles and forts, were shattered. The quake was felt in other parts of the world, including Togo.
1939	6.5	Experienced in Weija, Accra, Nyanyano and Gomoa Fete. 17 people were killed and 133 more were injured in Accra.
1964	4.5	Experienced in Akosombo.
1969	4.7	Experienced in Accra.
1997	3.8	Experienced in Accra
2003	4.8	Experienced in some parts of Accra
2012	4.2	Near the Coast of Accra
2013	4.7	Off the East Coast of Ghana
2014	4.6	Off the Coast of Takoradi
2015	4.5	Domeabra, Ashanti Region
2016	4.3	Hwidiem, Kumasi
2017	4.1	Gulf of Guinea, Near Coast of Ahobre, Ghana
2018	3.7	Accra, Ghana

Source: Field Work (2018)

Chapter Summary

This chapter reviewed literature related to this work and came up with the following highlights.

The majority of earthquakes are linked to weak zones in terms of time and/or space, which can be established from an earthquake hazard perspective. In Ghana, earthquakes are concentrated near the intersection of the Akwapim fault and the coastal boundary fault. Ghana's seismic activity is concentrated in the southeast, at the intersection of two major active faults.

Meteorologicaly rainfall has been shown to have a positive correlation with seismicity in Athens (Liritzis & Petropoulos, 1992). Accra has been identified to be mostly built on clays and sands and this makes groundwater conditions to be crucial to earthquake site response characteristics (Ayetey & Andoh, 1988). Kraft et. al., (2006) also estimated a significant correlation between seismicity, rainfall and groundwater level increases (Kraft el. al., 2006).

Geochemically, radon anomalies have been identified to have a relationship with seismicity. Increased radon gas concentrations are indicative of impending seismic activity (Furlan and Tommasino, 1993; Cartlidge, 2012; Tarakci et. al., 2013; Woith, 2015). Table 2.1 gives a brief background into the seismic history of Ghana. As can be seen, as far back as 1636, earthquakes have been recorded in the study area with 5.7M_w at Axim and about 3.7M_w at Accra.

CHAPTER THREE

RESEARCH METHODS

This chapter seeks to first give a general overview of the design implemented in carrying out this research, clearly spell out the study area and finally explain in detail how the work was done. Below are the research designs, study area and the methodologies relied on for the work.

Research Design

Many works have been done in the area of seismic hazard in Ghana (Amponsah et. al., 2012; Attoh et. al., 2005; Kutu el. al., 2013; Doku et. al., 2014, Ahulu et. al., 2018). Deterministic, probabilistic and geological, general geophysical and geochemical approaches have been used to predict seismicity in the country. This work falls on the absence of geochemical precursory relevance and dominance even though it has been proven to be one of the ways of identifying an impending earthquake. The study area receives a great amount of rainfall every year. The importance of precipitation as a pointer to seismic danger cannot be overstated. The mathematical model (b-value calculation by LLS and MLE), is also a follow-up to earlier calculations (Doku et. al., 2014) to authenticate the degree of stress which cannot be easily calculated except at the aftermath of an earthquake. The research design seeks to ensure that the research objectives are met. It is a well spelt out plan, structure and strategy put in place to help the research to meet the stated objectives (Kerlinger, 1978).

The design for this work is outlined in Table 3.1,

Table 3.1: Research Design Outlook

Objective	Type of Data	Source of Data	Method of Data Collection	Method of Data Analysis
Assess society and policy makers' knowledge of earthquakes and tremors	Knowledge on, precursors, pmergency response during earthquake hazard	All districts in GAMA (300 locals in GAMA -200 females and 100 males)	Survey by the use of questionnaire and oral test	Descriptive Statistics using KOBO and SPSS Programming language
Assess society and policy makers application of existing knowledge	Response during past events and response should event occur today	All districts in GAMA (300 locals of GAMA)	Survey by the use of questionnaire and oral test	Descriptive Statistics using KOBO and SPSS
Update existing catalogue to 2015 and then to 2018	Seismic events	USGS, USA, ISC, USA, GGSA via IRIS GHANA and GAEC	Online, GGSA Database and GAEC Database	Content analysis and descriptive statistics using MATLAB programming software

Source: Field Work (2018)

Table 3.1: Research Design Outlook Continued

Objective	Type of Data	Source of Data	Method of Data Collection	Method of Data Analysis
Evaluate b-value for 2015 and 2018	Database of seismic events	USGS, USA, ISC, USA, GGSA via IRIS GHANA GAEC	Online, GGSA Database GAEC Database	MATLAB Programming software to analyse seismic events database
Evaluate radon anomaly in GAMA	Information about radon level in GAMA	Boreholes in GAMA and surrounding areas	Groundwater sampling	SSNTD and EPERM
Relate radon anomalies to b-values	Interpretations from radon anomalies and b-values	Processed data from MATLAB, SSNTD & EPERM	Mathematical and Graphical Interpretations	Results interpretation and analysis using MATLAB and Counters Content Analysis
Relate precipitation to b-values	Interpretations from Precipitation data and b-values	Processed data from MATLAB, SSNTD & EPERM	Mathematical and Graphical Interpretations	Results interpretation and analysis using MATLAB and Counters Content Analysis
Evaluate Current Geology and Seismotectonics of GAMA	Knowledge on seismic events, radon analysis and precipitation analysis	Earthquake catalogue, SSNTD and EPERM results	MATLAB Programming SSNTD and EPERM results	Geology and Seismotectonic map interpretation Descriptive and Content Analysis of map generated

Source: Field Work (2018)

Study Area

Location

Ghana's capital city, Accra, is situated between 5° 30' and 0° 10' West and has a population of approximately two million five hundred and fifty-seven thousand people (GSS, 2021). GAMA is divided into five administrative districts, each covering about 1,000 square kilometers. This group comprises the Tema Metropolis, Accra Metropolis, Ga East Municipal, Ga West Municipal, Adenta Municipal and Ashaiman Municipal. GAMA is Ghana's largest industrialized region, as well as the country's most foremost educational, commercial, manufacturing, financial and trading center (Allotey et al., 2010). Map of the area under study is shown in Fig. 3.1

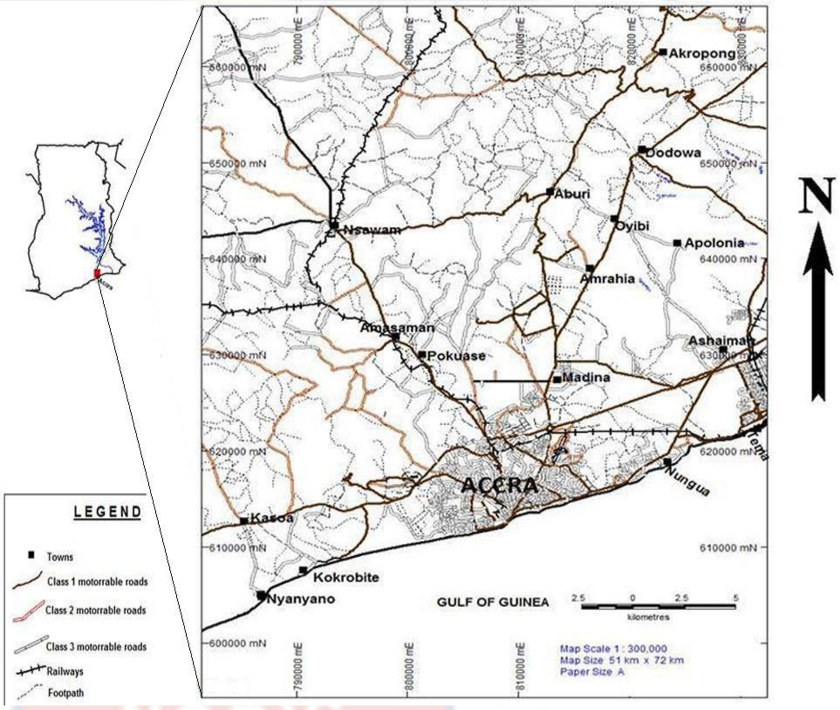

Figure 3.1: Topographical Map of Study Area (Doku *et. al.*, 2014)

Geology

There are six geological formations in GAMA (Fig. 3.1). They are,

Unconsolidated and Poorly Consolidated Sediments and Soils

Unconsolidated and poorly consolidated sediments and soils can be found at Abossey Okai, Korlebu, Mataheko, Dansoman, Achimota, Odorkor and Adabraka occurring from the Quaternary and Tertiary periods. Unconsolidated or Slightly Consolidated Cobble Colluviums, Marine Fluvial or Lacustrine Sediments, Red Continental Deposits, Consolidated Beach Sediments, and Unconsolidated or Slightly Consolidated Continental Deposits dominate this formation (Muff & Efa, 2006). The sandstones and mica schists are mostly thickly bedded in this area.

Devonian Accraian Group

Osu, North Kaneshie, Kpehe, Kanda, Alajo, and the city center of Accra are part of the Devonian Accraian Group, which includes the Lower Sandstone Formation, Middle Shale Formation and Upper Sandstone-Shale Formation (the capital). The majority of the land is underlain by sandstones with shale interbedded thickly layered sandstones.

The Voltaian Supergroup

The Voltaian Supergroup, which dates from the Lower Paleozoic, is primarily composed of Quartzose and impure sandstones. Anamorley, as well as parts of Olobu and Ablekuma, are covered by this system (Doku et. al., 2014).

Togo Structural Units

Phyllite, quartz veins and phyllonite, quartz schist (sericitic quartz schist), and quartzites make up the Togo Structural Units. Mandela, Weija, Anyaa, Nyanyano, Sowutuom, Oblogo, Burma Camp, Ofankor, Dome, Kwabenya, and parts of the GAEC are covered by this Structural Units. Togo Structural Units date from the Upper Precambrian Period. Quartzite minor mica schist, Granitoid and biotite gneiss, and thickly bedded sandstones are among the most important of these rocks.

The Dahomeyan Supergroup

The Dahomeyan Supergroup is made up of Middle-Late Precambrian basement rocks. Quartz schist, Metamicrogabbro, Orthogneiss, Amphibolites, and Scistose Marbles make up this group. Madina, as well as parts of GAEC and Mpehuasem, are on this formation. Garnet amphibolite gneiss underpins the Supergroup, which also includes Tema, Ashaiman, Nungua and Amrahia.

The Middle Precambrian Granitic Intrusions

These are Middle Precambrian Granitic intrusions which are made up of highly worn Granitoid-Pegmatite Complex. Amasaman, Adzen Kotoku, and Oduman, are part of the geology of the GAMA.

As shown in the geological map (Fig. 3.2), the geology of GAMA is generally interspersed with lineaments, concealed, observed, and thrust faults and shear zones. A broader view of the geological seismotectonics of Southern Ghana is shown in Fig. 3.3. GAMA's geology is characterized by non-uniformity, as seen by coastal boundary faults with mild stones along the shore, which are characterized by shear zones, joints, and fractures. Furthermore, they are older fault zones that have been reactivated as a result of a fragmentation of the continent (Singh et. al., 2009; Rajendran, 2000). Significant faults in the study area consist of the Longitudinal faults (Eastern boundary faults and Western boundary faults), faults parallel and sub-parallel to the coast, northerly striking faults and transverse faults.

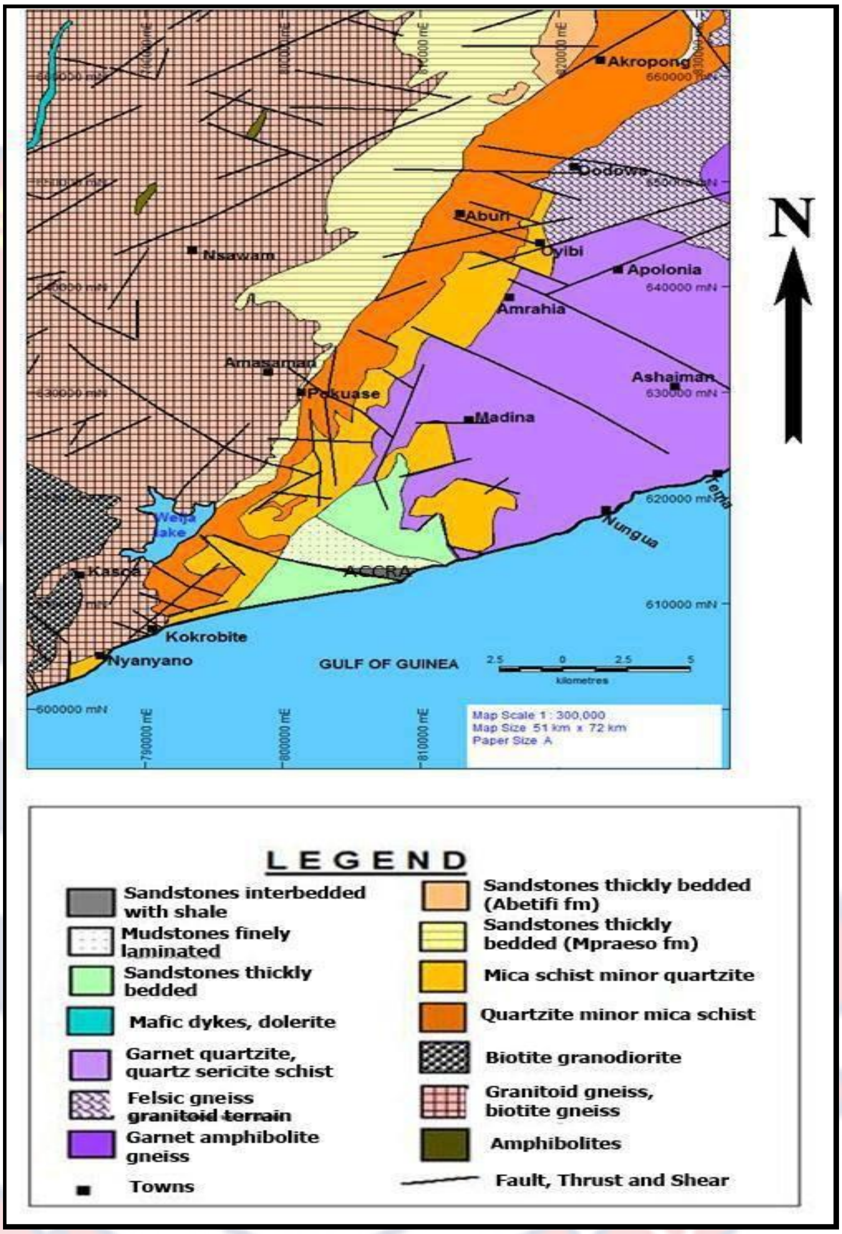

Figure 3.2: Geology of GAMA (Doku et. al., 2014)

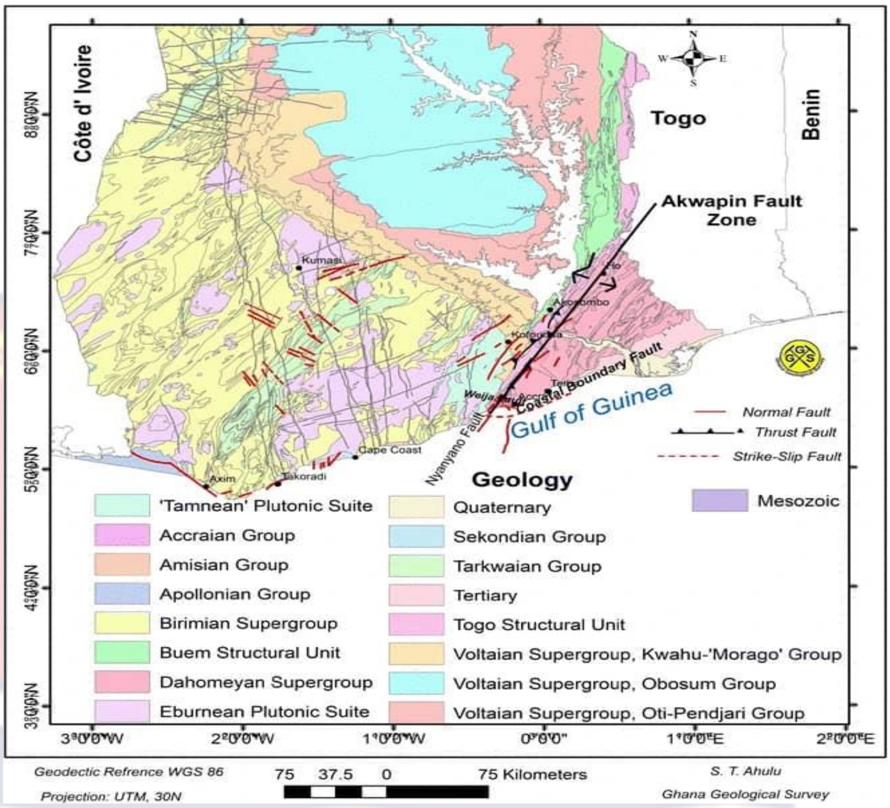

Figure 3.3: Geological Seismotectonics of Southern Ghana (Ahulu et. al., 2018)

Soils

Four main soil groups exist in GAMA. These are residual clays and gravels, alluvial and marine motted clays, and lateritic sandy clays (Muff & Efa, 2006; Kortatsi et al., 2008).

Wind-blown erosion deposits are the most common source of these drift materials, with alluvial and marine motted clays arising from underlying shales (Muff & Efa, 2006; Kortatsi et. al., 2008). Schist rocks, gneiss, and weathered quartzites yield residual clays and gravels, whereas laterite sandy clay degenerates from Accraian sandstone bedrock deposits. Many low-lying, poorly-drained locations have pockets of alluvial "black cotton" soils, which are constantly visible. GAMA's weathered rocks have a high organic content and can expand and contract quickly. This has a significant impact on foundations and footings (Muff and Efa, 2006; Kortatsi et. al., 2008).

Highly acidic laterite soils, which are found in some of these areas, can cause damage to concrete foundations. To a large extent, the result is honeycombing. Also near the foothills are areas of coalluvial laterite sands and gravels. Prevalent erosion types in the metropolis are:

Sheet erosion: This type of erosion occurs primarily on steeper foothill slopes as a result of poor farming practices that have resulted in the lack of natural vegetation cover.

Gully erosion: This type of erosion occurs primarily along major drainage channels.

Wind erosion: Only found along the coast and in dune areas. Coastal erosion is a major issue in the city (parts of the coastline are estimated to be retreating at a rate of 0.5 meters per year) (Muff & Efa, 2006; Kortatsi et. al., 2008).

Climate and Vegetation

Climate

The study's central point is Accra; which is located in the Coastal Savannah Zone. Accra has two major rainy seasons and an approximated annual rainfall of about 730 mm (in the two rainy seasons). May to Mid-July mark the first rainy season whilst Mid-August to October mark the second rainy season. Rain falls in short, intense storms, causing local flooding in areas with poor drainage. Temperatures vary little throughout the year, with mean monthly temperatures ranging from 24.7°C in August to 28°C in March (Doku et. al. 2014). The average annual temperature is around 26.8 °C. Because GAMA is closer to the equator, daylight hours are consistent throughout the year. The relative humidity level is generally high (i.e., about 65 percent at mid-afternoon to 95 percent at night). WSW to WNW is the predominant wind direction (wind speed is typically 8 to 16 kmh^{-1}). The GAMA's maximum wind speed is usually 107.4 kmh^{-1}, or about 58 knots. Slightly cooler temperatures on the Akwapim hills' foothill slopes result from increase in wind velocity (Muff & Efa, 2006; Kortatsi et. al., 2008).

Vegetation

The study area is pigeon-holed into terrestrial and aquatic vegetation. In the last century, the terrestrial vegetation has been altered as a result of climatic and other factors. Today, there are a few surviving trees visible in GAMA which was once engulfed in dense forest. GAMA's vegetation is similar to that of the Southern Shale, Guinea and Sudan Savannas, all of which are located north of the Accra plains. These are the consequences of climatic change, plain gradient, and land cultivation. Here are the broad terrestrial vegetative zones:

Shrub land: It can be found on the outskirts of town and in the Aburi hills to the north. There are dense clusters of shrubs and small trees that grow to a height of about 5 meters.

Grass land: They are a mixture of species found in forest undergrowth. The grasses are short, rarely exceeding one metre in length.

There are two types of vegetation in the coastal zone. The wetlands and dunes are among them.

The coast of GAMA is primarily dominated by mangroves and coconut plantations, with a number of new introductions of trees such as Neems, Mangoes, Casias, and Avocados, as well as palms and shrubs such as Bouganvillia, all of which are flourishing now.

Mangroves and salt marsh grasses make up the aquatic vegetation in GAMA. Sea grasses and attached algae can be seen around wave cut platforms and rocky areas, and they're common in the intertidal zone. Because of erosion, aquatic vegetation has increased in recent years (exposing bedrock particularly to eastern Tema). Sea grasses on the ocean floor are restricted to a few sheltered areas along the coast and in lagoons (Muff & Efa, 2006; Kortatsi et. al., 2008; Doku et. al., 2014).

Sampling Procedure

The sampling procedure involves data collection procedures and instruments and data processing and analysis as enumerated below.

Data Collection Instruments and Procedures

The data collection procedures and instruments used involve a desk study, earthquake catalogue development, data collection for precipitation studies (meteorological assessment) and sampling for radon (geochemical assessment). These are detailed in the following sections.

Desk Study

To obtain information of past seismic events of Ghana and her neighbours, the Accra Metropolitan Assembly, AMA, GGSA, the National Data Centre (NDC) of GAEC, the International Seismological Centre (ISC), the United States Geological Survey (USGS) and the Incorporated Research Institutions for Seismology (IRIS) were contacted. Data from previous studies were also used (Doku et. al., 2014).

Researches carried out in the area were also gathered in order to gain a thorough understanding of seismic activity in the study area (Amponsah, 2004; Ambraseys & Adams, 1986). Accra Central, Weija, Kwabenya, and Nyanyano were among the communities visited to assess infrastructural progress since the deadly earthquake of 1939. Short buildings are being replaced with high-rise storey buildings in Accra Central, for example. Weija is currently very developed, with modern structures, but the area also has a lot of unplanned settlements. Previous seismicity assessments have identified this area as having a high level of seismic activity (Amponsah, 2004; Ambraseys & Adams, 1986, Attoh et. al., 2005; Doku et. al., 2014). Land has been given out for development in Kwabenya and Nyanyano, but there is no attempt at building earthquake-resistant structures (even though the modern structures being put up in these areas are stronger than earlier ones).

Questionnaires were given out to indigenes living in the study area to ascertain their level of awareness of seismicity of the area as clearly elaborated in the research design.

Seismological Investigation (Earthquake Catalogue)

For hazard studies, the earthquake catalogue is the most essential parameter (Parvez et. al., 2001). This seismological, meteorological, and geochemical investigation used data from 1615 to 2018. The procedure for creating the earthquake catalogue is depicted in the flow chart (Fig. 3.4).

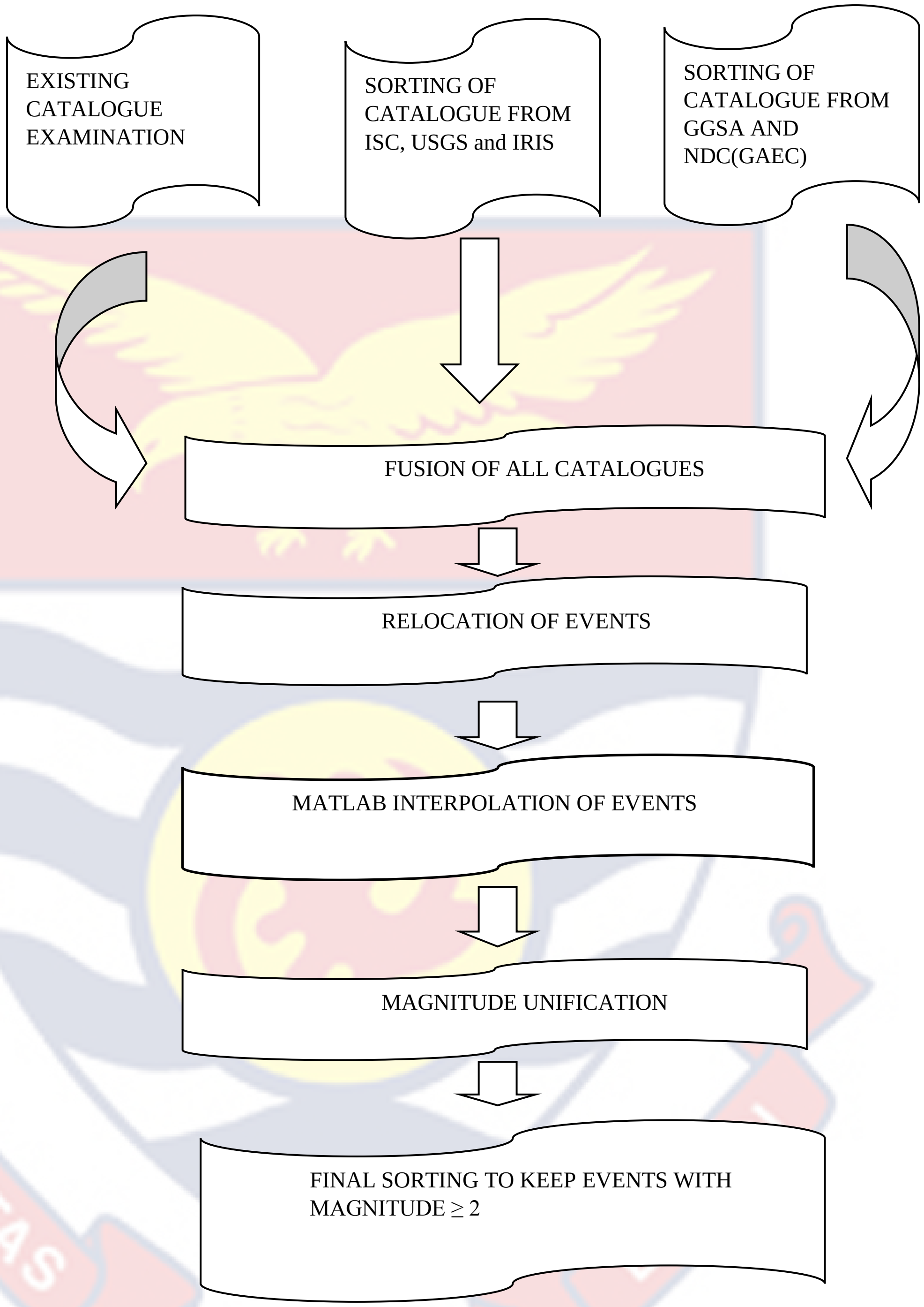

Figure 3.4: Seismicity Catalogue Flow Chart (Doku et. al., 2014)

Meteorological Investigation (Data Gathering for Precipitation Studies)

Precipitation data used over the period under investigation was obtained from the Ghana Meteorological Services. The data was picked for

Accra, Tema, Ada, Ho and Takoradi. The data was processed by estimating averages and maximum precipitations for the various areas and various years.

Geochemical Investigation (Sampling for Radon - Water and Soil)

300 ml plastic bottles, popularly referred to as sobolo bottles, were used to sample groundwater from some locations where the detectors were buried except Shai Hills where (access was denied to the drinking water of the wild life by the forestry commission). It was ensured that no bubbles were trapped in the bottles before being carefully sealed with aluminium foil and corked, ensuring radon tightness. As previously stated, care must be taken to completely fill the sample container to avoid systematic errors caused by radon accumulating in the void volume (Mauring & Gafvert, 2013).

The location of the sample, as well as the date and time of the water sample were meticulously recorded. To minimize measurement errors, the time between collection and analysis is monitored to be as short as possible (samples sent to the laboratory within one hour). The analysis of the sample is also started on arrival at the laboratory. They are quickly transported in an ice chest to the National Nuclear Research Institute (NNRI) of GAEC's Nuclear Track Detection Laboratory.

The radon detector setup for soil consists of two 0.25 m long PVC pipes with a diameter of 0.045 m and the same polyvinyl chloride (white) cork placed at one end of the same PVC pipe. The detector LR115 cellulose nitrate plastic material was cut to size 22 cm^2 and then attached to the PVC cork due to its high sensitivity and stability (Ansre et. al., 2017). The radon detector setups were then placed in 0.75 m deep pits and covered with an aluminium roofing sheet (40 x 30 cm^2) and sand for a 14-day period to simulate normal soil conditions. After a two-week period, the first set of detectors were retrieved and replaced with a second set of detectors that were retrieved after another two-week period (Asumadu-Sakyi et. al., 2011). The retrieved detectors were placed in envelopes and taken to the NNRI of GAEC for analysis at the Nuclear Track Detection Laboratory.

Data Processing and Analysis

This section involves data processing for earthquake catalogue unification and map development, processing of precipitation data and radon data unification.

Seismological Investigation

The catalogue unification and map developments involved an interpolation of earthquake magnitudes, relocation of events, magnitude unification, seismicity and intensity, isoseismals and evaluation of b-value.

Earthquake Catalogue Unification and Maps

The earthquake catalogue was generated from 1615 to 2018. Various magnitudes absent from captured events were filled in by interpolation using MATLAB programing software. This was followed by relocation of events using the google maps application software and the Global Positioning System, GPS, instrument. The magnitudes of these events in the catalogue were then unified into the moment magnitude unit (M_w). Seismicity, epicentral intensity and isoseismal maps were then generated using the Geographic Information System software. These processes are detailed in the next sections.

Interpolation of Earthquake Magnitudes

The magnitudes of events with no magnitudes from 1636 to 2012 were generated using Matlab Programming Software. Years and their magnitudes are among the input data. Some of them are 1636, 1862, and 2012, with average magnitudes of 5.8 M, 5.7 M, and 6.2 M, respectively (Doku et. al., 2014). This was carried out in the editor window. The output data was displayed after data entry and running in the command window. In the case of years with multiple records, an average of the event size was derived. The program was validated by commanding years of known magnitude events (Doku et. al., 2014). The program was then run, and the results confirmed the previously established magnitudes. A portion of this command window of the MATLAB programming is shown in Appendix B.

Relocation of Seismic Events

Some seismic events from Doku et al. (2014) were improved from Amponsah et al. (2012) (culled originally from the GGSA seismology section) and relocated to reflect the current day earthquake areas. This would aid in a better understanding of the GAMA's earthquake risk. The events' relocation aided in determining the finest intensity of the seismic events that might arise in modern-day Ghana. In certain circumstances, utilizing the Google Maps Application Software, the epicenter could not be readily detected. The location in question was found using the Global Positioning System (GPS) (at places like Donkunah, Weija, Nyanyano, Kwabenya, MacCarthy Hill and the City of Accra).

Magnitude Unification

Various magnitude units constitute the catalogue built. These magnitudes, presented in Table 3.2, were unified into the Moment Magnitude M_w by calculation.

Table 3.2: Magnitude Units

Magnitude	Symbol
Surface-wave Magnitude	M_s
Body-wave Magnitude	M_b
Duration Magnitude	M_D
Local Magnitude	M_L
Surface-Wave Magnitude for macroseismal data	MM
Moment Magnitude	M_w

Source: Doku *et. al.* (2014)

Unification and harmonization have become necessary because of the diversity of the events' magnitudes. Magnitude harmonization is done by converting all units to one single unit where applicable. Drawing a unified relationship between any of these scales would help to improve the data's homogeneity and consistency, allowing for improved hazard and risk assessment. Because the moment magnitude is a direct indicator of an occurrence's seismic moment, it was chosen. Some fault physical parameters, such as the amount of slide, have a strong relation with the magnitude (Doku et. al., 2014; Hanks & Kanamori, 1979; Mavonga & Durrheim, 2009).

Equations 3.1 to 3.10 were used for the conversion of the innumerable magnitude units to the Moment Magnitude, M_w. In situations where events were small, magnitudes M_L and M_b were chosen to provide reliable estimate of events (Hanks & Kanamori, 1979; Mavonga & Durrheim, 2009). Events spanning 1615 to 2003 were recorded in M_D, MM and M_L. Duration magnitude M_D was converted to M_L according to Brumbaugh (1987)

$$M_L = 0.936M_D - 0.16 \pm 22 \tag{3.1}$$

where;

M_L represents the local magnitude and M_D represents the duration magnitude

The linear regression expression (equation 3.1) has been used to evaluate magnitudes in regional and local seismic setups. The duration magnitude has the advantage of allowing quick estimates for a large number of local events (Brumbaugh, 1987).

According to Hanks and Kanamori (1979) and Mavonga and Durrheim (2009), other relationships used during synchronization include equation 3.2 to equation 3.9 (Hanks & Kanamori, 1979; Mavonga & Durrheim, 2009; Scordilis, 2006):

$$M_S = 2.08M_b - 0.5.65 \tag{3.2}$$

$$M_b = 0.481M_s + 2.716 \tag{3.3}$$

$$M_b = 1.7 + 0.8M_L - 0.01{M_L}^2 \tag{3.4}$$

$$\log_{10} M_O = 1.5M_S + 16.1 \pm 0.1 \qquad 5 \leq M_s \leq 7.5 \tag{3.5}$$

$$\log_{10} M_O = 1.5M_L + 16.0 \qquad 3 \leq M_L \leq 7 \tag{3.6}$$

$$M_S = 1.45M_L - 3.2 \tag{3.7}$$

$$M_{b,ISC} = 0.46M_S + 2.74 \tag{3.8}$$

$$M_W = \frac{(2\log_{10} M_O)}{3} - 10.7 \tag{3.9}$$

where;

M_s ⇨ the Surface-wave magnitude

M_b ⇨ the Body-wave magnitude

M_o ⇨ the Seismic moment

M_L ⇨ the Local magnitude

$M_{b,ISC}$ ⇨ the Body-wave magnitude according to the ISC standards

M_w ⇨ the Moment magnitude

Records captured in M_L and M_b at the NDC were kept when the translation resulted in a decline in magnitude. This would allow for more life-threatening earthquake consequences to be considered rather than relying on smaller earthquake magnitudes that can only be used to estimate less impact.

Epicentral Intensity Evaluation

Seismicity and Epicentral Intensity maps were generated to help put in perspective the frequency and intensity of events up to 2018. The intensity was evaluated from the earthquake magnitudes using Herak (2012) as

$$I = M_w + 2 \qquad 3.10$$

where;

I ⇨ the Epicentral Intensity

M_w ⇨ the Moment Magnitude

(Herak, 2012)

Evaluation of b-Value

Linear least square fit approach was employed to estimate the b-value. The Guttenberg-Richter method, also known as linear least square fit, employs the Guttenberg-Richter magnitude frequency relationship (Guttenberg & Richter, 1942). It is an empirical relation that expresses the relationship between magnitude and the total number of earthquakes in a given area over at least that magnitude's time period. It can be expressed as equation 3.11:

$$\log_{10} N\,(\geq M_w) = a - bM_w \qquad 3.11$$

where,

N ⇨ no. of events with magnitude ≥ M_w,

M_w ⇨ magnitude of the events,

a and b are constants. The seismic activity is described by 'a' (a logarithm of the number of events with $M_w = 0$). It is usually determined by the event rate, and for certain regions, it is determined by the volume and time window taken into account. The tectonic parameter b, which is usually close to 1, describes the relative abundance of large to smaller shocks. It appears to represent seismic medium properties in some ways, such as stress and/or material conditions in the focal region (Kulhanek, 2005).

When equation 3.11 is compared to the equation of a straight line (equation 3.12),

$$y = mx + c \tag{3.12}$$

where,

y ⇨ plots on the y- coordinate

x ⇨ plots on the x- coordinate

c ⇨ the y-intercept

m ⇨ the gradient of the plot of y against x

Then equation 3.11 can be re-written as:

$$y = \log_{10} N\ (\geq M_w) \tag{3.13}$$

$$x = M_w \tag{3.14}$$

and the gradient

$$m = -b \tag{3.15}$$

$\log_{10} N\ (\geq M_w)$ was calculated from the developed earthquake catalogue with the conforming aggregate (cummulaltive) magnitudes, The stress (b-value) (i.e. slope of the graph) was calculated using the results obtained from plotting equation 3.13 against equation 3.14, as described in equations 3.11 to 3.15. One remarkable feature of this technique is that all the $\log_{10} N\ (\geq M_w)$ values evaluated take part in the calculation (Chen et. al., 2003).

To estimate the b-value by the Maximum Likelihood Estimation Method, Marzorcchi and Sandri (2003), Lombardi (2003), and Felzer (2006) were applied to estimate the b-value by the maximum likelihood process using the mathematical model (Marzorchhi & Sandri, 2003; Lombardi, 2003; Felzer, 2006; Doku et. al., 2014)

$$b = \frac{1}{[\ln 10\ (m_{av} - m_c)]} \qquad 3.16$$

where;

b ⇨ b-value

m_{av} ⇨ average magnitude from the catalogue and

m_c ⇨ the cut off magnitude (usually carefully selected from the sharp curve exhibited by chart).

The estimation of the threshold magnitude m_c is very critical. Usually, m_c magnitude of data set is evaluated from plotting $\log_{10} N\ (\geq M_w)$ against the magnitudes M_w. This cut off magnitude m_c, is the level at which the data falls below the line of best fit (Lin et al., 2008; Wang and Shieh, 2004).

New insights into the estimation of the b-value and its associated uncertainty were revealed in reviews by Marzorcchi and Sandri (2003) (Marzorcchi & Sandri, 2003). This included the introduction of the maximum likelihood estimation method and subsequent calculations of the associated uncertainties, whereas Lombardi (2003) applied the maximum likelihood estimator to calculate the b-value of mainshocks and compared the results to the Guttenberg-Richter least square fit method (Lombardi, 2003). Felzer (2006) used the maximum likelihood estimation method to calculate Californian seismicity rates from the earthquake catalogue for time-independent hazard analysis (Felzer, 2006).

The b-value ambiguity (uncertainty) was calculated using Aki (1965)

$$\sigma_b = \frac{b}{\sqrt{N}} \qquad 3.17$$

σ_b represents the uncertainty, b represents the b-value and N represents the number of earthquakes under consideration (Aki, 1965).

Seismicity, Epicentral Intensity and Isoseismal Maps

Isoseismal maps were generated using the Geographic Information System software. This was done for the general catalogue generated and then zoomed in to the study area for detailed appreciation of the hazard correlation of the displayed geographically referenced information processed (Wald et. al., 1999).

To generate an isoseismal map using a geographic information system (GIS), the following steps were followed

1. Data was obtained on the intensity of the earthquake at various locations from the earthquake catalogue (Appendix A) developed and eye witness reports from KOBO research.
2. This data was imported into the GIS software package (QGIS).
3. A base map of the sub-region was created using a suitable map projection and scale.

4. Intensity data was then used to create isoseismal contours on the base map. These contours show the boundaries between different intensity levels, such as "very light," "light," "moderate," and "severe".
5. Labels were then added to the map to identify the intensity levels and the corresponding isoseismal contours. (Wald & Allen, 2007; Dias & Soares, 2008; Sousa & Cruz, 2016)

Meteorological Investigation

Processing Precipitation Data

Precipitation data used for the period under investigation was obtained from the Ghana Meteorological Agency. The data was picked from synoptic stations along the coastal belt. Collated daily precipitation data was processed by estimating averages and maximum precipitations for every year. These data were then plotted to estimate precipitation trend. Then, again plotted against earthquake magnitudes recorded.

Geochemical Investigation

Solid state nuclear track detector (SSNTD) method and the EPERM method were used to analyze the radon samples.

Solid State Nuclear Track Detector (SSNTD) Method

Radon data for 2018 was not available. Field work was carried out from January to December 2018 to complete the geochemical assessment. As shown in Fig.3.5, all radon concentration data were obtained using the passive method (LR-115, Desirae Company, France) and E-PERMS (Rad Elec Inc., Maryland, USA). After the exposure, the detectors were removed from the envelopes. Each detector is fixed on a string (A). A 100 g sodium hydroxide pellet (NaOH) weighed in a beaker with an electric balance was then used to

amount of radon in the water is also determined. The components of the radon in water test kit include:

1. Ten (10) 68 ml sampling bottles with teflon gasket screw caps.
2. Excel templates on cd for radon in water calculations.
3. Radon in water manual.
4. S chamber, electrets and a SPER1 reader (not included in the radon in water test kit).
5. Two (2) 3.72 l glass measurement jars with rubber sealing collars as shown in Fig. 3.6

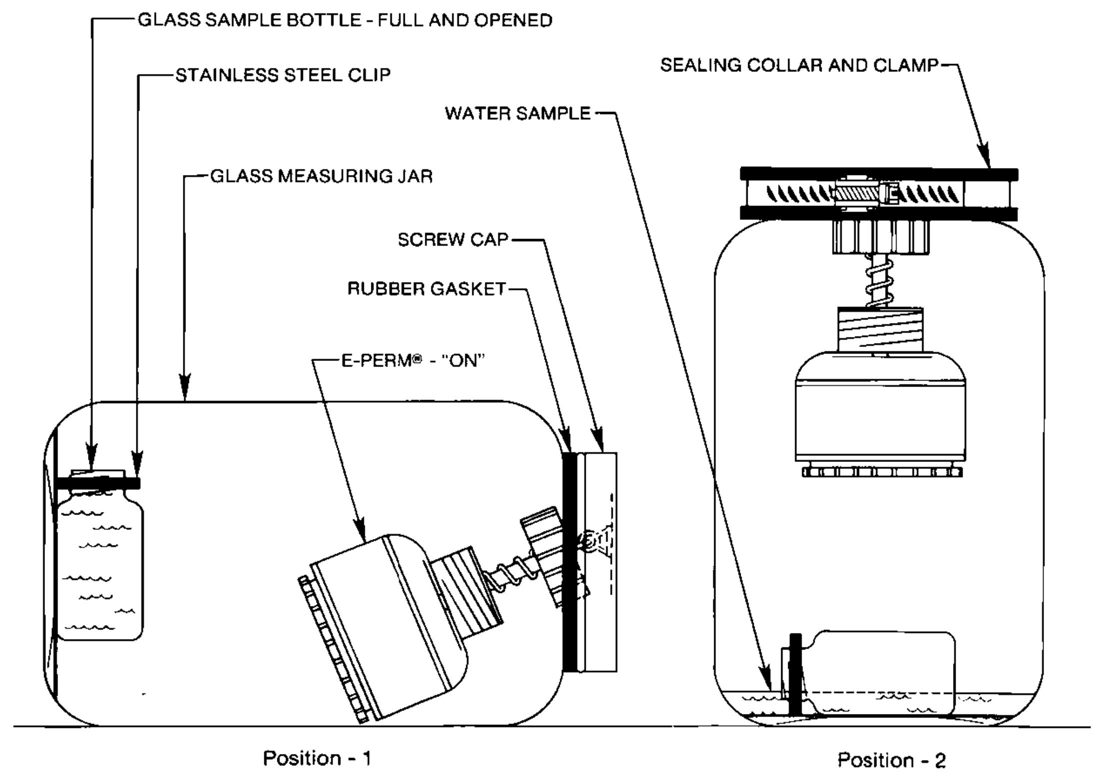

Figure 3.6: E-PERM$^{®}$ system (radon-in-water measurement)

Procedure

1. Each of the measurement jars had an EPERM suspended in the air above the water. To make the measurement jars radon-tight, the lids were closed and sealed.

2. The EPERM measured when radon reached equilibrium between water and air.
3. The measurement jars were opened and the EPERMs were removed at the end of the desired exposure period. The data gathered and recorded were then entered into the Radon in Water Test Kit's Excel spreadsheet, which then used to calculate the radon concentration in the air.
4. The radon concentration in the water sample was calculated using the radon in air concentration and the other data.

Steps to Collect Radon in Water Sample

1. For sampling from wells, the cold water was allowed to run for about ten minutes at a medium rate to ensure that the water sample comes directly from the well and not from connecting pipes or water tanks.
2. Three sampling bottles were gently filled, allowing each to overflow for a few seconds while keeping a meniscus above the brim of the bottle.
3. The cap was immediately screwed tightly on the sampling bottle it ensured that no air bubbles were entrapped.
4. The date and time the water sample was taken, as well as the location where it was taken were recorded.
5. The bottles were carefully packed to avoid damage. To reduce measurement errors, the time between collection and analysis was kept as short as possible. As a result, sample analysis was usually started as soon as the sample is received in the laboratory.

Duplicate radon in water measurement was done whilst adhering to the following protocols.

1. The EPERM was prepared by measuring the initial voltage (V_i) of the

electrets, loading the electret into the S Chamber, and unscrewing the top of the S Chamber to the "ON" position just before the measurement begins.

2. On a table, a large glass measuring jar was placed horizontally on its side. The lid (screw cap), sealing collar, and screwdriver for the glass measuring jar were all kept nearby.

3. The sampling bottle's cap was gently opened and the open bottle is inserted all the way to the bottom of the jar into the clip while the measurement jar remained horizontal (See Fig. 3.8.).

4. The cap of the large measuring jar was screwed onto the jar as the open EPERM was hung on the "hook" on the inside of the cap. The measuring jar was carefully brought to the vertical position. The water in the sampling bottle could now spill to the bottom of the bottle. To prevent radon loss from the large measuring jar, the cap was quickly tightened.

5. The rubber sealing collar was installed around the cap, with the thinner side flush with the white cap and the thicker side closest to the glass jar. With a screwdriver, the clamp around the collar was tightened while keeping the measuring jar vertical.

In the next steps the real procedure was undertaken

a. A record of the test's date and time of start was kept.

b. To accelerate the release of radon into the measuring jar, the jar was gently shaken (only the water was moved; to ensure that the water sample bottle was not damaged).

c. The measuring jar was placed in a vertical position to ensure that it is not disturbed during the exposure period (usually 2 days).

d. The clamp was loosened after the exposure period to remove the collar.

The EPERM was then removed by unscrewing the lid of the measuring jar.

e. After that, the time and date of the removal was recorded.

f. The final electret voltage was then recorded (V_f)

g. The sample bottle was removed and the water was discarded from the measuring jar and the sample bottle.

h. The bottle was allowed to dry after rinsing with low-radon water.

If an unusually high concentration of radon was recorded, the bottle was well rinsed with water that had been boiled.

Calculating the Concentration of Radon in Water

Records obtained in the above processes were entered in the specific fields of the Excel sheet and the concentration was calculated automatically by the designed sheet.

Theory

Spark Counting Procedure (Track Replication)

To enlarge the track, the detectors were pre-sparked at 1003 V and then re-sparked three (3) times at 1000 V. The replica sparks on the Aluminized Mylar were counted using a Microfiche Reader and a Tally Counter after they were sparked.

Track Density

The track density, ρ, is defined as the average number of counts per unit area of the electrode. Mathematically expressed as:

$$\rho = \frac{Average\ number\ of\ counts}{Area\ of\ electrode} \qquad 3.18$$

The track density is calculated using the average number of counts obtained from three consecutive counts on each detector.

Using Equation 3.19, the area of the field of view, A, was calculated from the diameter (d) of the circular shape of the electrode.

$$A=\frac{\pi d^2}{4} \qquad 3.19$$

where d = 0.8 cm

Thus, area of the electrode = 0.5027 cm^2

The radon concentration, C_{Rn}, was evaluated in kBq/m^3 after the calculation of the track density, using equation 3.20

$$C_{Rn} = \frac{track\ density\ (\rho)-background\ density(\rho\mathcal{B})}{calibration\ factor\ (\varepsilon)\times exposure\ time\ (T)}\ (kBq/m^3/hrs) \qquad 3.20$$

Relating Seismological and Meteorological Assessments

Yearly average seismic event data were plotted against yearly average precipitation in order to establish a correlation between seismological and meteorological geohazard. Pearson's correlation coefficient was subsequently calculated.

Relating Seismological and Geochemical Assessments

Yearly average seismic event data were plotted against yearly average geochemical data (radon concentrations) in order to establish a correlation between seismological and geochemical geohazard. Pearson's correlation coefficient was subsequently calculated.

KOBO and SPSS (Did You Feel It?) Assessment

The survey captured some background information of respondents who participated in the study. This includes those who have ever experienced earth tremor or quake, time of tremor or quake, observations during the earthquake, whether they were awake or asleep, whether neighbours felt it, description of the shaking, reaction during the shaking and how respondents describe the shaking. This is because the study recognized the relevance of background factors as most of these influence the variables under the analysis. Summary of the background factors is then presented in the form of a pie chart.

Chapter Summary

Here is a summary of the methodologies or procedures used and how this has been clearly designed in GAMA. The research methodology comprised field work (burying radon detectors and sampling) and laboratory experimentation, collection of data (precipitation and seismic) from the Ghana Meteorological Agency (GMA), GAEC, USGS, ISC and GGSA. The seismological work covers the use of seismic events; the meteorological work involved the manipulation of precipitation data whilst the geochemical research part of the work involved the radon processes. About one thousand seven hundred (1700) seismic events were collected and processed. Also, 100 radon detectors were buried at various homes and public places in the study area and removed for laboratory processes after fourteen (14) days.

Results, observations and general outcome of activities are enumerated in chapter four. Here is a summary of procedure and/or methodology used to obtain results:

a) Collecting, processing and analysing seismic data from NDC (GAEC), GGSA, USGS, ISC, and Doku et. al., 2014.
b) Collecting, processing and analysing meteorological data from synoptic stations in the southern belt.
c) Burying radon detectors 75 cm deep in 25 cm diameter holes into the ground and removing them after 14 days and administering questionnaire via KOBO subsequently (a Did You Feel It (DYFI) survey to investigate the degree of awareness about tremors and quakes

by residents in the study area. This was done online by creating the questionnaire and administering online to about three hundred and ten residents). Sampling ground water and administering questionnaire via KOBO subsequently.

d) Collecting and analyzing geochemical data obtained in c).

e) Processing and interpreting the outcome of a), b), c), and d) using GIS, MATLAB, SPSS and KOBO softwares.

f) Plotting Seismicity against yearly average precipitation in order to establish a correlation between seismological and meteorological geohazard.

g) Plotting Seismicity against yearly average geochemical data (radon concentrations) in order to establish a correlation between seismological and geochemical geohazard.

h) Pearson's correlation coefficient was subsequently calculated in f) and g)

CHAPTER FOUR

RESULTS AND DISCUSSION

The research sets out to assess society and policy makers' knowledge of earthquakes and tremors, and how they apply to existing knowledge. Again, it must be emphasized that the research sets out to create an improved, comprehensive and homogeneously unified earthquake catalogue for Ghana from 1615 to 2018. Also, to evaluate the stress level of GAMA by calculating the b-value from the catalogue using the Linear Least Square Fit Procedure (1615-2015 and 1615-2018). It is also to generate an improved seismicity map, an upgrade of Doku et. al., (2014). Produce an improved epicentral intensity map for GAMA. Establish a relationship between GAMA's geology, stress, precipitation and general seismicity.

Seismological Investigation

Earthquake Catalogue (1615-2018)

The earthquake catalogue has been generated by the various processes enumerated in the methodology. The highest moment magnitude events occurred in 1858, 1861 and 1862. These are interpolated events whose magnitudes were not recorded by the seismographs. They occurred at Akropong Akwapim, Kpando and Apam respectively. The lowest tremor recorded is a 1.1 M_w that occurred at Nyamiyeadi. The catalogue reveals many earth tremors as compared to earthquakes in and around the country. Earthquakes and tremors in Ghana are generally not very strong, but they can still cause damage to buildings and infrastructure.

The epicentral intensities calculated reveal a lot of the events have ≥ 6 intensity even though most record a high degree of shallow depth. The most common type of earthquake or tremor ha been observed to be a "shallow focus". This means most of the events occur at depths of less than 70 kilometers below the Earth's surface. These types of earthquakes/tremors are often felt more strongly than deeper earthquakes, as the energy from the earthquake is able to travel more easily through the Earth's crust and into the surface. The detailed catalogue is captured in Appendix A.

Plot of Events

As seen in Fig. 4.1, the plot shows a sparing distribution from 1636 to 1975 and a high density of events from 1975 to 2018. Beyond 1975, events have seen many recordings and this has shifted the density to the right. The most pronounced events are seen to be densely concentrated in the new millennium (year 2000 and beyond). The sparing distribution starts from 1636 to 1861/1862 when two major events occurred within these two years but no magnitude and intensity were recorded. Their interpolated magnitudes however churned out 6.6 M_w. Appendix B shows all the generated magnitudes. Fig. 4.2 further shows that a lot of events have magnitudes $\leq 3\ M_w$ before the deadly earthquake of 1939 that took 17 lives and injured 133 others (Amponsah, 2004). A check on the epicentre of this event reveals it occurred at sea. An inland epicentre would have recorded a higher disaster.

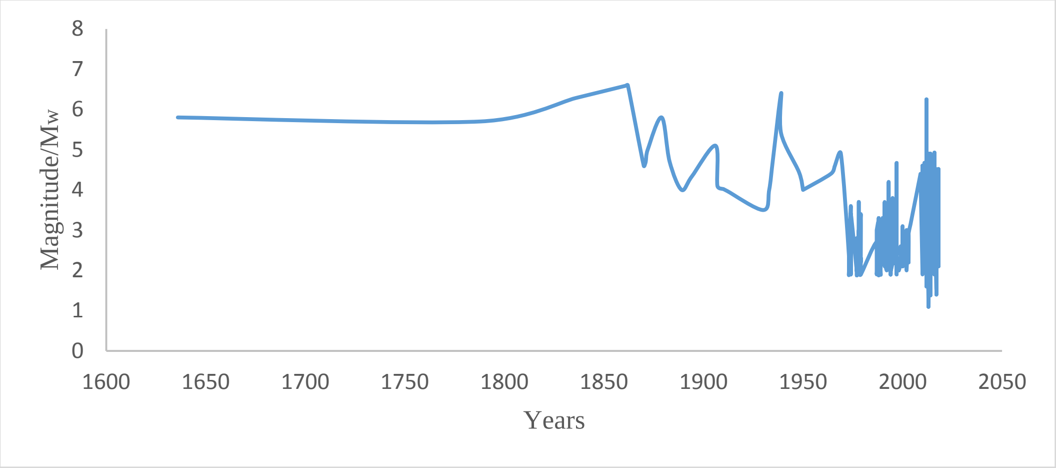

Figure 4.1: Plot of the Magnitude of the Seismic Events from 1615-2018

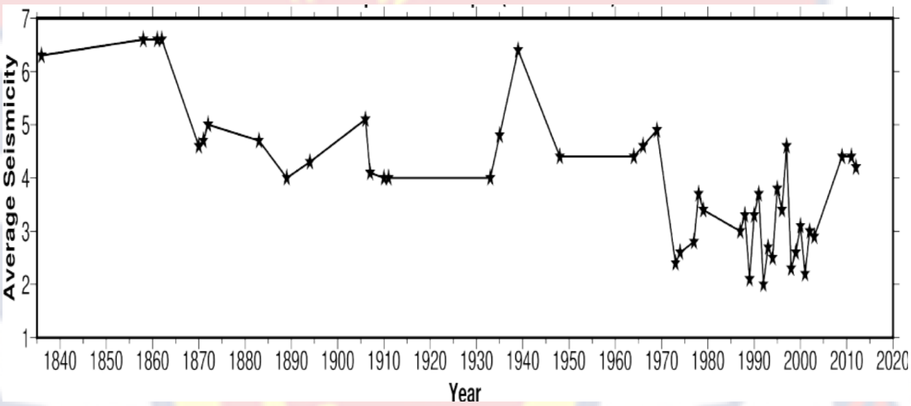

Figure 4.2: Plot of the Average Seismic Events from 1836-2018

The next peak that can be observed clearly from the plot is the 1969 event, a 4.9 M_w major tremor that struck and caused damages in Accra. In this case, no lives were lost. This major event was also followed by a lot of tremors in subsequent years. On March 6, 1997, a 4.6 M_w tremor occurred. Even though it did not meet that of 1939 and 1969, it was well felt in and around Accra since a lot of structures in the area are still not up to seismic standards to withstand major earthquakes. Building codes have not been adhered to (Allotey et. al., 2010). Allotey et. al., (2010) also observes that the damage will have been greater if not for an improvement in the type of structures built and the creation of awareness by education. The next peak is a 5.1 M_w, it occurred on December 6, 2012, when cross-checked from the catalogue. This occurred in Duekoue, Cote D'Ivoire near Ghana's western boarder. Most events after these fall between 3 M_w and 4.8 M_w. It is possible these tremors are precussors to major and significant earthquakes in the near future as can be observed in the eraticity of the plot in Fig. 4.2 from 1836 to 2018. Also, the density of events seen in the plots in recent years is an indication of the occurrence of tremors frequently as compared to previous years.

The b-VALUES

A total of five hundred and sixty-nine (569) events from 1615 to 2012 were used to calculate the b-value. For 1615 to 2015, one thousand and eighty-six (1086) events were used for the plot and calculation. Between 1615 and 2018, one thousand four hundred and fifty-three (1453) events were used. All the moment magnitudes used ranged from ≥ 2 Mw to ≥ 6.5 Mw. The magnitudes, M_w, were then plotted against $\log_{10} N\ (\geq M_w)$ (Fig. 4.3, Fig. 4.4 and Fig. 4.5).

The plots were used to estimate b by fitting a straight line to a plot of the magnitude of earthquakes versus the logarithm of the frequency of such magnitudes recorded. Table 4.1, Table 4.2 and Table 4.3 show the statistical tabulations and calculations undertaken to evaluate b-value by the Gutenberg-Richter model.

Table 4.1: b-value Calculation by Gutenberg-Richter Model (1615-2012)

M_w	$N \geq M_w$	$Log(N \geq M_w)$
2	569	2.75511227
2.5	454	2.65705585
3	417	2.62013605
3.5	394	2.59549622
4	263	2.41995575
4.5	37	1.56820172
5	15	1.17609126
5.5	11	1.04139269
6	6	0.77815125
6.5	3	0.47712125

Source: Field Work (2012)

Table 4.2: b-value Calculation by Gutenberg-Richter Model (1615-2015)

M_w	$N \geq M_w$	$Log(N \geq M_w)$
2	1086	3.035829825
2.5	870	2.939519253
3	807	2.906873535
3.5	772	2.8876173
4	589	2.770115295
4.5	73	1.86332286
5	16	1.204119983
5.5	11	1.041392685
6	8	0.903089987
6.5	3	0.477121255

Source: Field Work (2015)

Table 4.3: b-value Calculation by Gutenberg-Richter Model (1615-2018)

M_w	$N \geq M_w$	$Log(N \geq M_w)$
3	1132	3.053846427
3.5	1082	3.034227261
4	812	2.909556029
4.5	81	1.908485019
5	16	1.204119983
5.5	11	1.041392685
6	8	0.903089987
6.5	3	0.477121255

Source: Field Work (2018)

The b-value estimated from Fig. 4.3 as enumerated in the methodology to be the coefficient of x is 0.57 with an R² value of 0.92. Thus, the variation in the regression is 92% explained by the independent variable M, the magnitude of events.This shows that the relationship between the independent varaiable x (M$_w$) and the dependent variable $\log_{10} N\ (\geq M_w)$ is very strong. A little change in M$_w$ will result in a significant change in $\log_{10} N\ (\geq M_w)$. R² is the fraction by which the variance of the errors is less than the variance of the dependent variable, M$_{w.}$ The R² value however depreciates by 0.01 for 1615 to 2015 (Fig. 4.4) and repeats same for 1615 to 2018 (Fig. 4.5) but still remains at significantly strong relationship of 0.90. Fig. 4.4 and Fig. 4.5 show that the b-value calculatd LLS are 0.64 and 0.68 respectively. This improvement in results can be attributed to the increase in the number of seismic events under consideration in each case (Hanks & Kanamori, 1979; Mavonga & Durrheim, 2009).

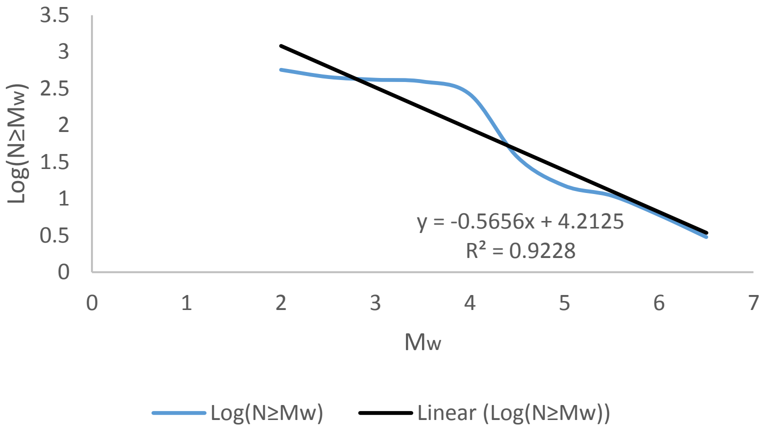

Figure 4.3: Gutenberg-Richter Model Plot (1615-2012)

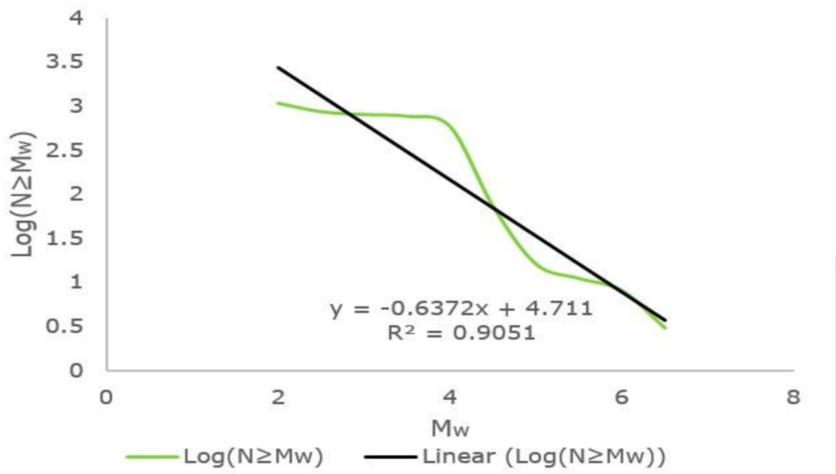

Figure 4.4: Gutenberg-Richter Model Plot (1615-2015)

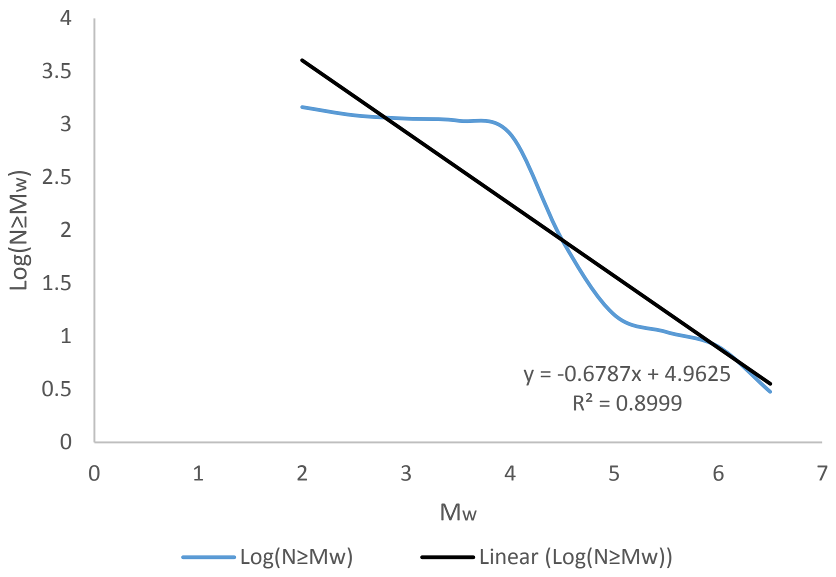

Figure 4.5: Gutenberg-Richter Model Plot (1615-2018)

The MLE method, also an improved form of the Gutenberg-Richter estimate, is a statistical technique used to estimate the b-value of a particular region such as GAMA. As discussed by Wiemer and Wyss (2000), the importance of accurately estimating the b-value and the challenges that can arise when doing so by the MLE method can influence earthquake hazard assessment (Wiemer & Wyss, 2000). Mavonga & Durrheim (2009) recognize a careful selection of the cut off magnitude m_c from the Gutenberg-Richter model plot for a good MLE evaluation (Mavonga & Durrheim, 2009). To calculate the b-value using the MLE method, there's the need to have data on the sizes (magnitudes) of past earthquakes in the region of interest. There are several different statistical models that can be used to estimate the b-value, including the Gutenberg-Richter model and the MLE model. The choice of model will depend on the characteristics of the data and the specific goals of the analysis (Wiemer & Wyss, 2000; Zechar & Jordan, 2006). Here, the MLE model is chosen to make up for the weakness in Gutenberg-Richter model when dealing with very large data set that have the probability of having a lot of significant tremors and earthquakes.

$$b = \frac{1}{[\ln 10\,(m_{av} - m_c)]}$$

The average magnitude evaluated for 1615-2012 after estimating an m_c of 4.5 from its plot is 5.0 M_w. Usually, the average magnitude is calculated from the the cut off magnitude to the highest magnitude. In this case $4.5 \geq Mw \geq 6.6$. Forty-seven (47) events were obtained out five hundred and sixty-nine (569) to give this average. With

$m_{av} = 5.0$ and m_c=4.5

$$b = \frac{1}{[\ln 10\,(5.0 - 4.5)]}$$

$$b = 0.869$$

This process was repeated for 1615-2015 and 1615-2018. Table 4.4 details b-values evaluated by LLS and MLE.

Table 4.4 Summary of b-values by LLS and MLE

RANGE (YR)	LINEAR LEAST SQUARE		MAXIMUM LIKELIHOOD ESTIMATION	
1615 – 2012	0.57	$R^2 = 0.923$	0.87	$\sigma_b = 0.126$
1615 – 2015	0.64	$R^2 = 0.905$	0.97	$\sigma_b = 0.116$
1615 – 2018	0.68	$R^2 = 0.900$	0.79	$\sigma_b = 0.126$
AVERAGE	0.63	0.909	0.88	0.123

Source: Thesis Results (2020)

Once the b-value has been calculated, it can be used to estimate the likelihood of future earthquakes in the region and to assess the potential impacts of these earthquakes on infrastructure and human populations. It is important to note, however, that the b-value is only one factor that should be considered when making these estimates, and other factors, such as the underlying geology of the region, must also be taken into account (Kanamori & Koyama, 1973; Wiemer & Wyss, 2000). The b-value is typically used in combination with other geophysical data like the GIS generated maximum seismicity, epicentral intensity and isoseismal maps to estimate the likelihood of future earthquakes in a particular area. It is an important tool for earthquake hazard assessment and risk management.

And average LLS value of 0.63 with an R^2 value of 0.909 as compared to an MLE average of 0.88 with its corresponding ambiguity (uncertainty), σ_b of 0.123 shows an improved b-value. According to the result of the maximum likelihood method, there may be high rheological strength in the crust (Bilim, 2019). Frequent seismic activity in GAMA has however not been observed until recent times. This average estimated b-value from the MLE may be resulted from increased shear, thrust and fractures in GAMA's geology. In addition, high b-value may be associated with thin crust in the study region.

Seismicity, Epicentral Intensity and Isoseismal Maps

After converting the files to comma-separated values, CSV files and saving the events in a table structured format, the csv files were imported as x-y plot onto the base map (geological map) of Ghana and its neighboures. Various layers were then added before the extraction of GAMA hazard map as shown in Fig. 4.10. The map of maximum intensity of Ghana and its neighbours however, shows a major concentration of seismic activities in Cote D'Ivoire with seismicity between 5 M_w and 6 $M_{w.}$ It can be observed that Ghana has records of a lot of earth tremors ≤ 3 M_w (Fig. 4.6). It is clear from Fig. 4.7 that the most frequent tremors occurring are those ≤ 3 in the study area.

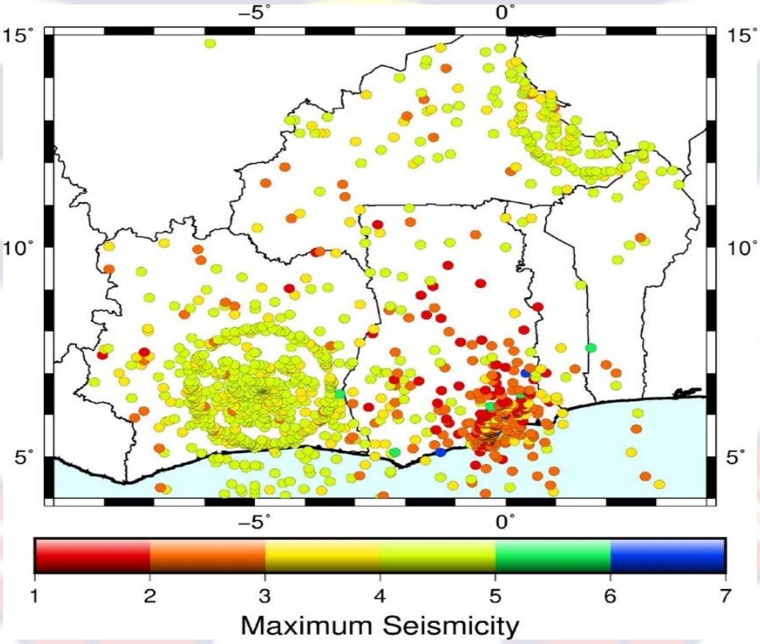

Figure 4.6: Maximum Seismicity Map of Ghana and Its Immediate Neighbours

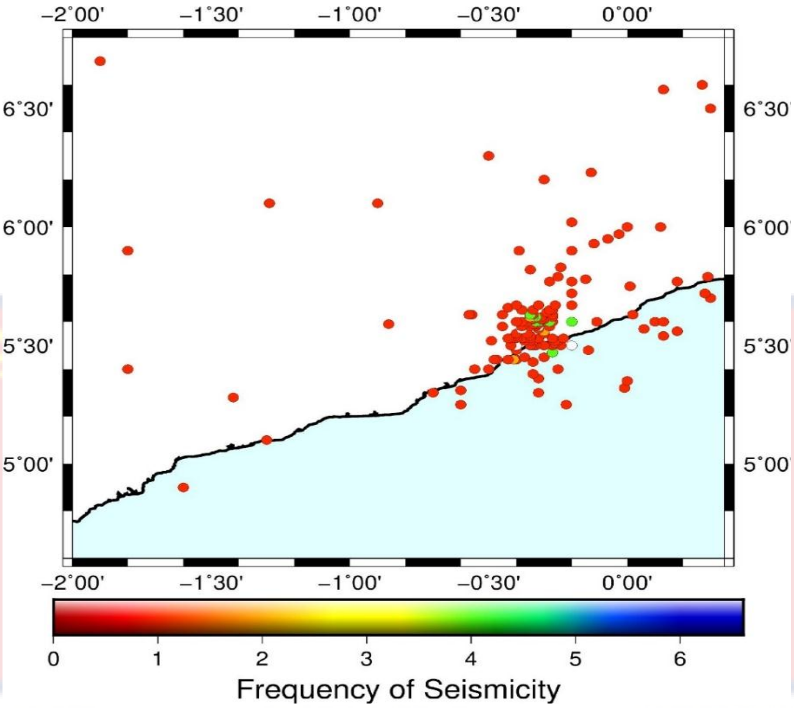

Figure 4.7: Frequency of Seismicity Map of GAMA

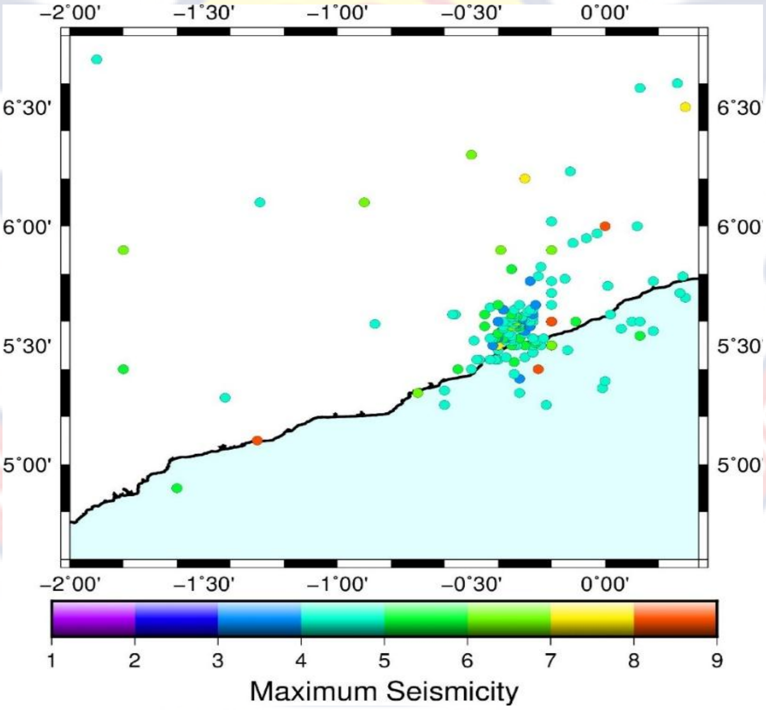

Figure 4.8: Maximum Epicentral Intensity Map of GAMA

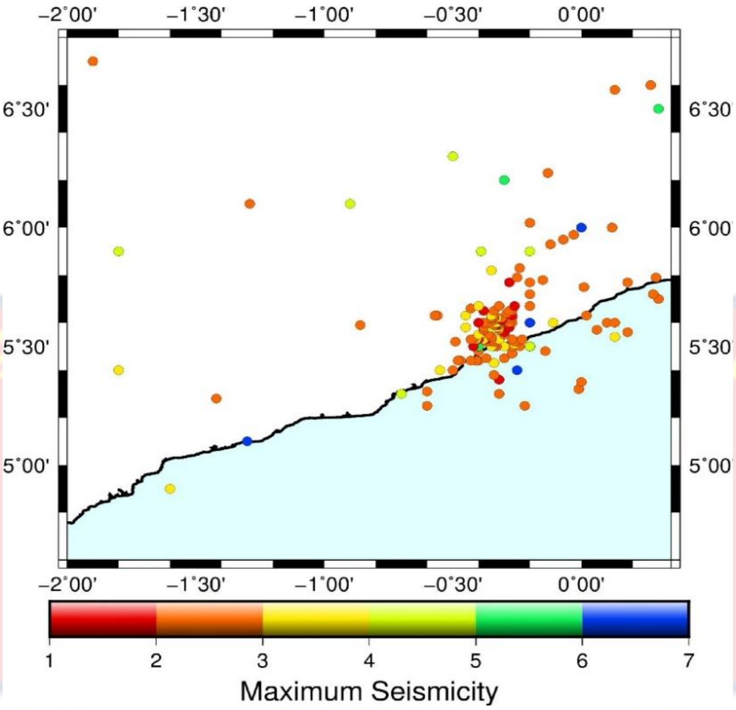

Figure 4.9: Maximum Seismicity Map of GAMA

This maximum seismicity of events occurs around Weija, MCcarthy Hill, Kwabenya, Legon and their environs (Fig. 4.9). There are at least three (3) major events of epicentral intensity VIII observed in these areas (Fig. 4.8). One of the three events occurred offshore. Offshore earthquakes, sometimes called tsunamis can result in a very high degree of retribution such as observed in Sendai, Japan in 2011 (Raskob, 2020). As observed in GAMA, offshore earthquakes are becoming prevalent. The Great Tohoku tsunami and earthquake of March 11, 2011, took about eighteen thousand five hundred (18500) lives. It also affected the Fukushima-Daiichi nuclear plant. The magnitude 9 M_w occurred 150 km off the subduction zone (Raskob, 2020). This means offshore earthquakes in the isoseismals in Fig. 4.10 too must be well studied.

The isoseismal maps, Fig 4.10 and Fig 4.11 show areas of equal seismicity. Weija in GAMA, Yamoussoukro and Abidjan in Cote D'Ivoire are on the same isoseismal. Within GAMA, Weija, Madina, Nungua, Nyanyano and North eastern Akropong fall within the same isoseismal and can experience earthquakes with an approximate epicentral intensity of VIII (this area is very active seismically as seen in Fig. 4.7, Fig. 4.8 and Fig. 4.9). The maximum seismicity map also shows that a lot of the events occurring in and around Ghana's capital are below 5 M_w with one or two drops of major earthquakes.

One notable observation which can be described as serendipity is the ring of seismic events appearing in Cote d'Ivoire that needs further probe. The events as can be seen are not of low magnitude but rather$\geq$ 5 Mw.

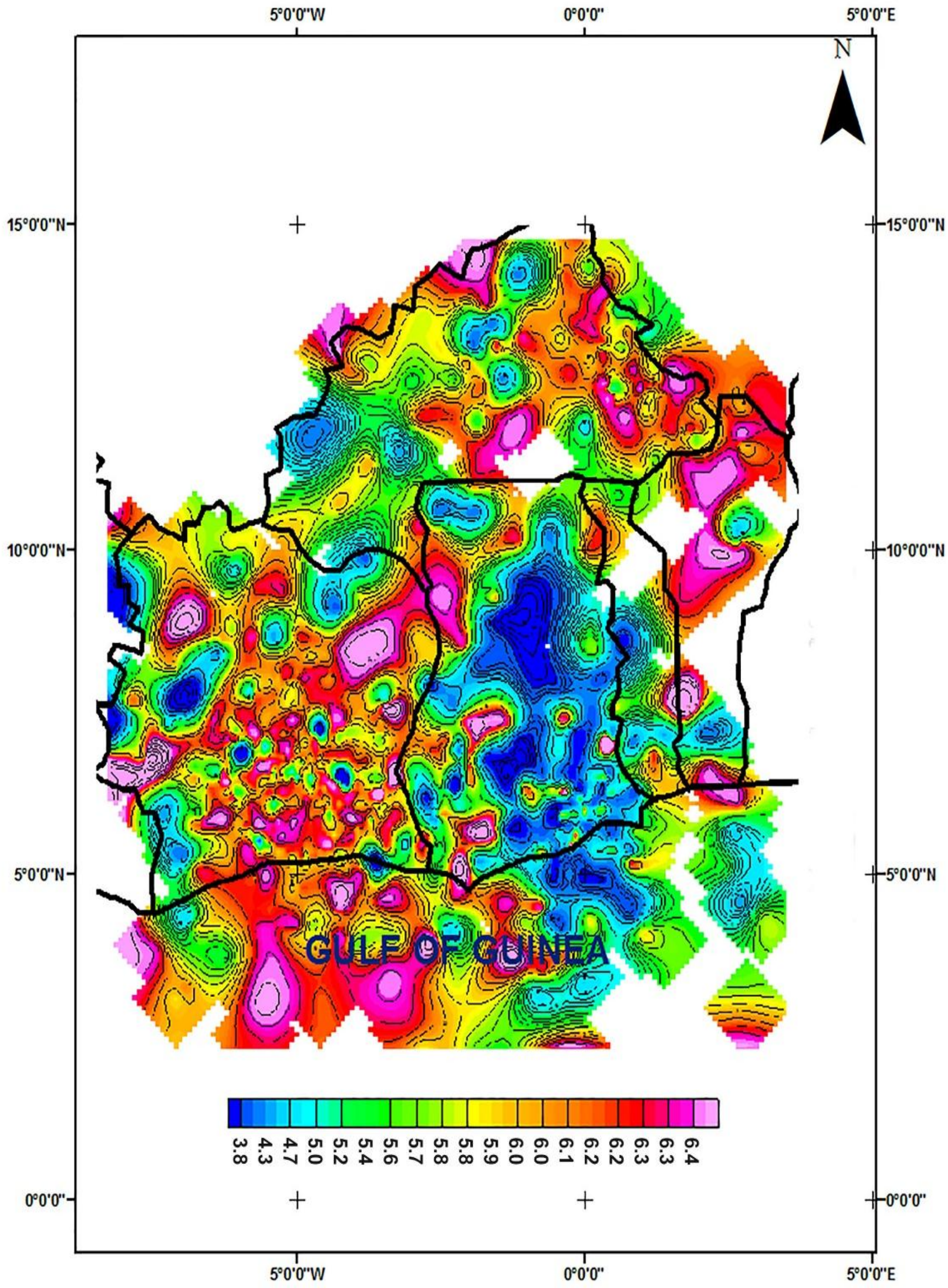

Figure 4.10: Isoseismal Map of Ghana and Its Immediate Neighbours

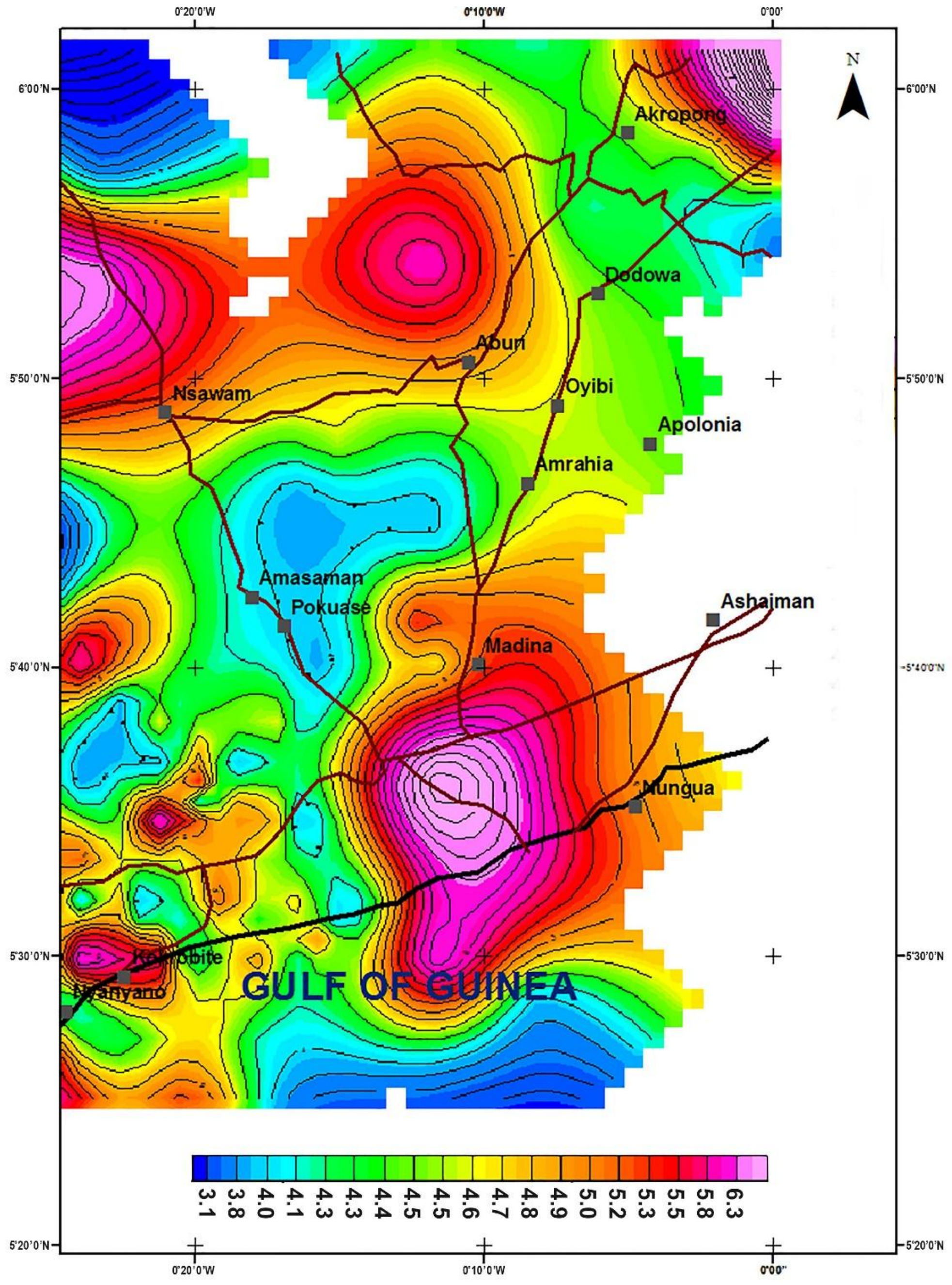

Figure 4.11: Isoseismal Map of GAMA

Just as can be seen in other empirical measures and intensity, the isoseismal map shows regular distribution patterns and dimensions of the felt area of events experienced from 1615 to 2018 first for Ghana and its immediate neighbours and then Ghana (Southern Ghana) in focus. These indicators can help seismologists to estimate the size and relative depth of most events that have been recorded over the period under investigation.

In fact, the isoseismal map provides an indirect measure of the magnitude or energy released by seismic events by measuring the size of the areas over which the earthquakes were felt at various intensities. The size of the areas over which the shocks were felt can thus be used to estimate the magnitude of earthquakes.

Although intensity at a given point tells engineers little about ground motion, isoseismal maps, in the construction of which intensities' estimates undergo a significant amount of averaging and smoothing of in-built biases, provide a useful tool with which one can assess the magnitude.

With these maps generated current ground motions can be evaluated through the use of earthwquake magnitudes and not directly by local Intensity (Chandra, 1979). These are earthquakes affecting more than one country, where individual intensity maps prepared separately for each country frequently do not match across national borders (Tertulliani et. al., 1999).

Meteorological Investigation Results

The precipitation data from the synoptic stations were averaged per year as in the case of the seismic events (Table 4.5). The seismic events were then plotted against precipitation per year to arrive at Fig. 4.12.

Table 4.5: Average Precipitation Per Year

Year	M_W	Precipitation
1987	2.61	1062.84
1988	2.31	975.85
1989	2.05	917.75
1990	2.82	710.28
1991	2.55	1137.13
1992	2.00	637.80
1993	2.35	785.43
1994	2.18	824.15
1995	2.76	1063.47
1996	2.61	1105.00
1997	2.61	1282.75
1998	2.29	644.10
1999	2.42	964.57
2000	2.10	717.92
2001	2.43	907.90
2002	2.63	1027.82
2003	3.15	961.35
2004	3.78	876.75
2005	4.02	920.28
2006	3.59	900.07
2007	4.14	1095.68
2008	4.21	1064.33
2009	4.40	927.33
2010	4.27	1096.90
2011	3.90	1015.48
2012	2.96	884.12
2013	2.36	704.57
2014	2.69	1127.08
2015	3.97	1019.58
2016	3.39	910.43
2017	3.06	1117.65
2018	3.54	1315.23

Source: Thesis Results (2018)

Relating Seismological and Meteorological Assessments

The absence of precipitation data before 1985 for the study area can be clearly seen in Fig. 4.12. A positive correlation between these data and average seismicity can be seen after 1985 with the peak occurring before the new millennium. A major correspondence between precipitation and seismicity can be seen from the year 2000 to 2018.

As can be seen in Fig. 4.12, peak values of seismicity started emerging between 1993 and 1996. Major correlations between seismicity and radon can be observed in 2000, between 2005 and 2009, 2012, 2015 and finally in 2018. With this observation the absence of data around 2004 can be assumed to follow the same trend if present.

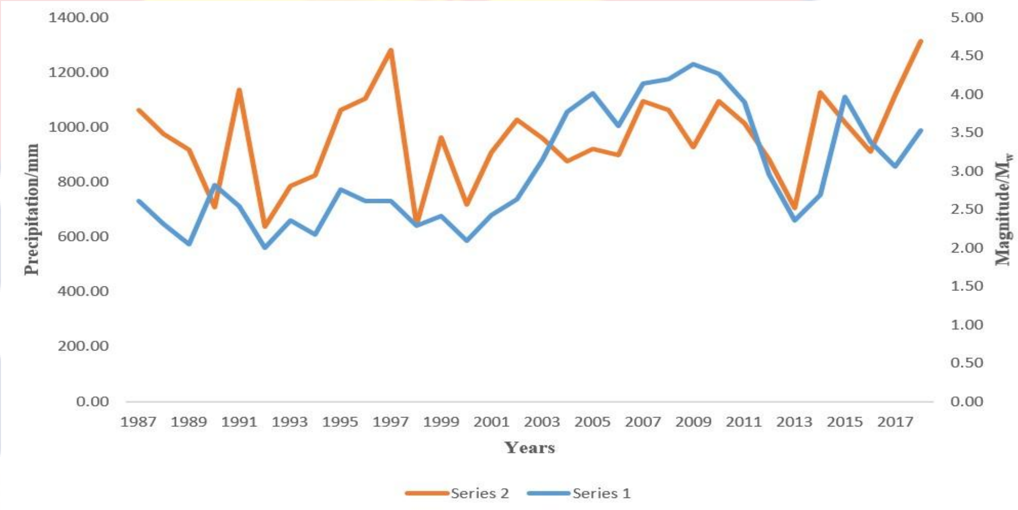

Figure 4.12: Plot of Precipitaiton Against Average Seismicity

Pearson's Correlation Coefficient

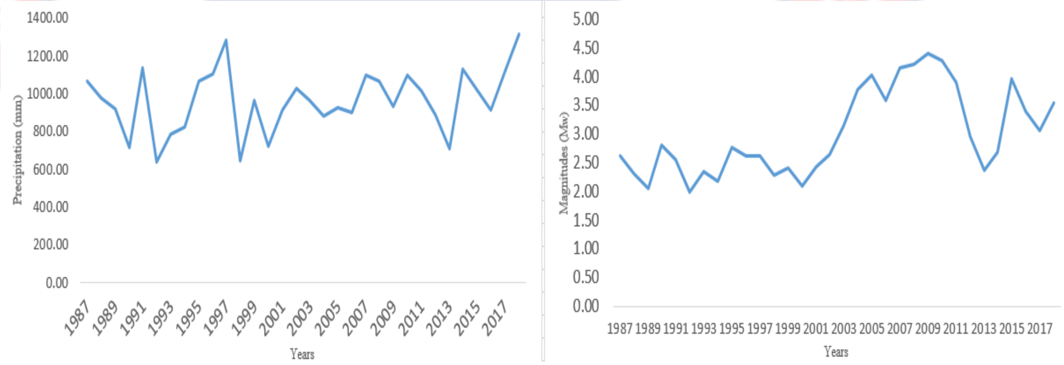

Figure 4.13: Pearson's Correlation Plot (1987-2018)

A not very strong positive correlation of 0.4 exists between precipitation and seismicity with a t-statistic of 2.12. With a p-value as 0.04, it can be concluded that there is a linear relationship between precipitation and seismicity. This statistical measure quantifies the strength of the relationship between the two variables, precipitation and seismicity (Chen et. al., 2009).

A p-value of 0.04 indicates that there is a 4% chance that the observed result occurred by chance. In other words, there is a 96% chance that the observed result is due to a real difference between the groups being compared (Bollinger et. al., 2008; Ji et. al., 2006).

Geochemical Investigation Results
Laboratory Analysis
SSNTD Process

Table 4.6: Radon in Water by SSNTD

Code	Count	Error Count	Track density	Background	Error Background	Background Track Density	EXP (d)	Actual Track Density	Error on Actual Track Density	Calibration Factor x Time	Conc. kBq/m^3	Lat	Lon	Locations
13	408	20.1990099	408	10	3.16227766	10	92	398	19.94993734	87.4368	4.551859171	5.52764	-0.3491	Donkunah
14	461	21.4709106	461	10	3.16227766	10	92	451	21.23676058	87.4368	5.158011272	5.52646	-0.3482	Donkunah
15	135	11.61895	135	10	3.16227766	10	92	125	11.18033989	87.4368	1.429604011	5.52213	-0.348	Donkunah
16	153	12.3693169	153	10	3.16227766	10	92	143	11.95826074	87.4368	1.635466989	5.5235	-0.3515	Donkunah
17	168	12.9614814	168	10	3.16227766	10	92	158	12.56980509	87.4368	1.80701947	5.55664	-0.3032	Weija
18	157	12.5299641	157	10	3.16227766	10	92	147	12.12435565	87.4368	1.681214317	5.55749	-0.3032	Weija
19	123	11.0905365	123	10	3.16227766	10	92	113	10.63014581	87.4368	1.292362026	5.57113	-0.3346	Weija
20	99	9.94987437	99	10	3.16227766	10	92	89	9.433981132	87.4368	1.017878056	5.68728	-0.253	Kwabenya
21	163	12.7671453	163	10	3.16227766	10	92	153	12.36931688	87.4368	1.74983531	5.68711	-0.2512	Kwabenya
22	175	13.2287566	175	10	3.16227766	10	92	165	12.84523258	87.4368	1.887077295	5.69059	-0.2474	Kwabenya

Source: Laboratory Results from Thesis Work (2018)

From Table 4.6, the concentration of radon in water was calculated using equation 3.20. The detectors have been exposed to the radon in water bottled for 92days. This gives a total exposure time of

$$92\ x\ 24hours = 2208hours$$

$$C_{Rn} = \frac{track\ density\ (\rho) - background\ density(\rho\mathcal{B})}{calibration\ factor\ (\varepsilon)\ \times exposure\ time\ (T)}\ (\mathrm{kBq/m^3/hrs})$$

Using Sample Code 13 for example, the radon concentration was calculated by subtracting the background density from the track density ($track\ density\ (\rho) - background\ density(\rho\mathcal{B})$) and then dividing the result by the already built in product of the difference between the calibration factor and the exposure time ($calibration\ factor\ (\varepsilon)\ \times exposure\ time\ (T)$).

$$C_{Rn} = \frac{408-10}{87.4368}$$

$$C_{Rn} = 4.55\mathrm{kBq/m^3}$$

Standard calibration factor can be obtained by using a standardized concentration of a known volume of radon and calculating it by making the calibration factor the subject of equation 3.20 with all other factors constant. Here, sample code 14 recorded the highest concentration of 5158.011272 kBq/m^3 in Donkunah whilst the lowest concentration of radon in water recorded was 1.01788 kBq/m^3 which was obtained at Kwabenya. These values are all higher than the WHO standard of 200 Becquerels per cubic meter (Bq/m^3) for long-term exposure. This is based on the fact that radon is the second leading cause of lung cancer, and long-term exposure to high levels of radon can increase the risk of developing lung cancer (WHO, 2009; WHO, 2013; WHO, 2020).

Table 4.7 represents radon in soil results obtained by SSNTD method.

Table 4.7: Radon in Soil by SSNTD

Code	Count	Error Count	Track density	Back ground	Error Background	Back ground Track Density	EXP (d)	EXP (h)	Actual Track Density	Error on Actual Track Density	Calibration Factor x Time	Conc. Bq/m3	Lat	Lon	Locations
1	2761	52.54521862	2761	10	3.1622777	10	15	360	2751	52.44998	142.56	19297.1	5.52764	-0.3491	Donkunah
2	2531	50.30904491	2531	10	3.1622777	10	15	360	2521	50.20956	142.56	17683.8	5.52764	-0.3491	Donkunah
3	2575	50.74445783	2575	10	3.1622777	10	15	360	2565	50.64583	142.56	17992.4	5.52646	-0.3482	Donkunah
4	2338	48.35286961	2338	10	3.1622777	10	15	360	2328	48.24935	142.56	16330	5.52646	-0.3482	Donkunah
5	2963	54.4334456	2963	10	3.1622777	10	15	360	2953	54.34151	142.56	20714.1	5.52213	-0.348	Donkunah
6	2721	52.16320542	2721	10	3.1622777	10	15	360	2711	52.06726	142.56	19016.6	5.52213	-0.348	Donkunah
7	2252	47.45524207	2252	10	3.1622777	10	15	360	2242	47.34976	142.56	15726.7	5.5235	-0.3515	Donkunah
8	2284	47.79121258	2284	10	3.1622777	10	15	360	2274	47.68648	142.56	15951.2	5.5235	-0.3515	Donkunah
9	2482	49.81967483	2482	10	3.1622777	10	15	360	2472	49.71921	142.56	17340.1	5.52755	-0.3504	Donkunah
10	4164	64.52906322	4164	10	3.1622777	10	15	360	4154	64.45153	142.56	29138.6	5.52899	-0.351	Donkunah
11	5188	72.02777242	5188	10	3.1622777	10	15	360	5178	71.95832	142.56	36321.5	5.55377	-0.313	Weija
12	4553	67.47592163	4553	10	3.1622777	10	15	360	4543	67.40178	142.56	31867.3	5.55377	-0.313	Weija
13	4277	65.39877675	4277	10	3.1622777	10	15	360	4267	65.32228	142.56	29931.3	5.55664	-0.3032	Weija
14	4032	63.49803147	4032	10	3.1622777	10	15	360	4022	63.41924	142.56	28212.7	5.55664	-0.3032	Weija
15	3493	59.10160742	3493	10	3.1622777	10	15	360	3483	59.01695	142.56	24431.8	5.55749	-0.3032	Weija
16	3764	61.3514466	3764	10	3.1622777	10	15	360	3754	61.26989	142.56	26332.8	5.55749	-0.3032	Weija
17	3550	59.58187644	3550	10	3.1622777	10	15	360	3540	59.4979	142.56	24831.6	5.57113	-0.3346	Weija
18	3896	62.41794614	3896	10	3.1622777	10	15	360	3886	62.33779	142.56	27258.7	5.57113	-0.3346	Weija
19	4440	66.633325	4440	10	3.1622777	10	15	360	4430	66.55825	142.56	31074.6	5.68728	-0.253	Kwabenya

Source: Laboratory Results from Thesis Work (2018)

Table 4.7: Radon in Soil by SSNTD Continued

Code	Count	Error Count	Track density	Back ground	Error Background	Back ground Track Density	EXP (d)	EXP (h)	Actual Track Density	Error on Actual Track Density	Calibration Factor x Time	Conc. Bq/m3	Lat	Lon	Locations
20	4188	64.71475875	4188	10	3.1622777	10	15	360	4178	64.63745	142.56	29307	5.68728	-0.253	Kwabenya
21	3914	62.56196928	3914	10	3.1622777	10	15	360	3904	62.482	142.56	27385	5.68711	-0.2512	Kwabenya
22	4923	70.16409338	4923	10	3.1622777	10	15	360	4913	70.0928	142.56	34462.7	5.68711	-0.2512	Kwabenya
23	1731	41.60528813	1731	10	3.1622777	10	15	360	1721	41.48494	142.56	12072.1	5.69059	-0.2474	Kwabenya
24	1684	41.03656906	1684	10	3.1622777	10	15	360	1674	40.91455	142.56	11742.4	5.69059	-0.2474	Kwabenya
25	1937	44.01136217	1937	10	3.1622777	10	15	360	1927	43.89761	142.56	13517.1	5.69001	-0.2507	Kwabenya
26	1777	42.15447782	1777	10	3.1622777	10	15	360	1767	42.0357	142.56	12394.8	5.69001	-0.2507	Kwabenya
27	1449	38.06573262	1449	10	3.1622777	10	15	360	1439	37.93415	142.56	10094	5.6896	-0.251	Kwabenya
28	1240	35.21363372	1240	10	3.1622777	10	15	360	1230	35.07136	142.56	8627.95	5.68892	-0.2574	Kwabenya
29	1580	39.74921383	1580	10	3.1622777	10	15	360	1570	39.62323	142.56	11012.9	5.6839	-0.0471	Tema
30	1811	42.55584566	1811	10	3.1622777	10	15	360	1801	42.43819	142.56	12633.3	5.68244	-0.0242	Tema
31	1954	44.20407221	1954	10	3.1622777	10	15	360	1944	44.09082	142.56	13636.4	5.88234	0.0383	Shai Hills
32	1168	34.17601498	1168	10	3.1622777	10	15	360	1158	34.0294	142.56	8122.9	5.88175	0.03662	Shai Hills
33	1727	41.55718951	1727	10	3.1622777	10	15	360	1717	41.4367	142.56	12044.1	5.88864	0.03865	Shai Hills
34	3765	61.35959583	3765	10	3.1622777	10	15	360	3755	61.27805	142.56	26339.8	5.90647	0.04389	Shai Hills

Source: Laboratory Results from Thesis Work (2018)

Same calculations as carried out in Table 4.6 were undertaken to arrive at concentrations for radon. But the exposure time for the investigation on soil radon as can be seen in Table 4.7 is 15 days. Again, the highest concentration was observed in Weija ($\cong 36kBqm^{-3}$). Kwabenya also recorded the lowest radon in soil value of about $8kBqm^{-3}$. Shai Hills also records some low values of radon, just a little above the lowest detection at Kwabenya. All these figures however still remain higher than the WHO recommended values (WHO, 2020).

EPERM Process

After exposing the detectors to the electret-ironization chamber of the EPERM for 3-days at an initial and final voltage between 750v and 770v, the radon concentrations as shown in Table 4.8 were obtained. It is important to note that most of the emanations occurred at Weija, the most seismically active area observed in the seismological and meteorological investigations. At a final voltage of 744 v, a concentration of 8 $kBqm^{-3}$ was recorded. The second highest radon concentration however occurred at final voltages of 743 v and 755 v (7 $kBqm^{-3}$). The lowest concentrations of radon, 2 $kBqm^{-3}$, were however recorded at final voltages of 759 v, 745 v, 760 v and 748 v by the EPERM process. It is safe to understand and establish that within these voltage ranges optimal radon ionization occurs and the alpha particles that form the tracks to be read appear most for etching. These records occurred at Donkunah and Kwabenya. Radon concentrations obtained by EPERM are detailed in Table 4.8.

Table 4.8 Radon in Water by EPERM

Code	Initial Voltage	Final Voltage	Conc. kBq /m^3	Lat	Lon	Locations
1	764	759	2	5.52764	-0.34907	Donkunah
2	764	757	3	5.52646	-0.3482	Donkunah
3	750	745	2	5.52213	-0.34799	Donkunah
4	764	760	2	5.5235	-0.35152	Donkunah
5	772	765	3	5.55377	-0.31296	Weija
6	765	754	6	5.55664	-0.30315	Weija
7	759	744	8	5.55749	-0.30324	Weija
8	757	743	7	5.57113	-0.33462	Weija
9	748	736	6	5.68728	-0.253	Kwabenya
10	753	748	2	5.68711	-0.25115	Kwabenya
11	768	755	7	5.69059	-0.24736	Kwabenya
12	754	744	4	5.69001	-0.25065	Kwabenya

Source: Laboratory Results from Thesis Work (2018)

Table 4.9 shows the summary of the average radon results obtained in Ghana. The year 2018 recorded the highest average concentration of approximately 32kBqm^{-3} whilst in 1990 an average radon concentration of 9.40 Bqm^{-3} was recorded (the least average radon concentration). Over the years it can be observed that more and more radon works done have resulted in an improvement in radon detection. It is therefore safe to say that earlier works were challenged in instrumentation and detection methods. Also, over the years, suture and fracture zones have increased in number, faults have continued to expand in the face of renewed tremor activities and these can also alter the concentrations of radon detected. Some years have gone without any radon work and this makes it difficult to get data for proper analysis. Records are absent for the year 1992 and from 2002 to 2006. Fig 4.14 details the average radon peaks. A detailed table of areas of radon work and concentrations detected can be located in Appendix C. Table 4.9 also represents the yearly radon averages analysed geochemically.

Table 4.9: Average Radon Concentration Per Year

Year	Average Radon Conconcentration/Bqm^{-3}
1989	91.80
1990	9.40
1991	779.90
1993	144.400
1994	5726.00
1999	27000.00
2001	71.00
2007	4235.90
2008	25920.00
2009	132.70
2010	466.90
2011	1720.00
2012	16020.00
2014	753.51
2015	2155.00
2016	1193.00
2018	31946.52

Source: Laboratory Results from Thesis Work and Nsiah-Akoto (2010)

These radon concentrations recorded over the years in Table 4.9 are plotted to observe key emanations in specific years (Fig. 4.14). Here, lowest radon anomalys are observed in 1993 and 2009. Very high radon concentrations are observed in 1999, 2008 and 2018. What appears like a 10-year interval in appearance of high concentrations occurs within these periods.

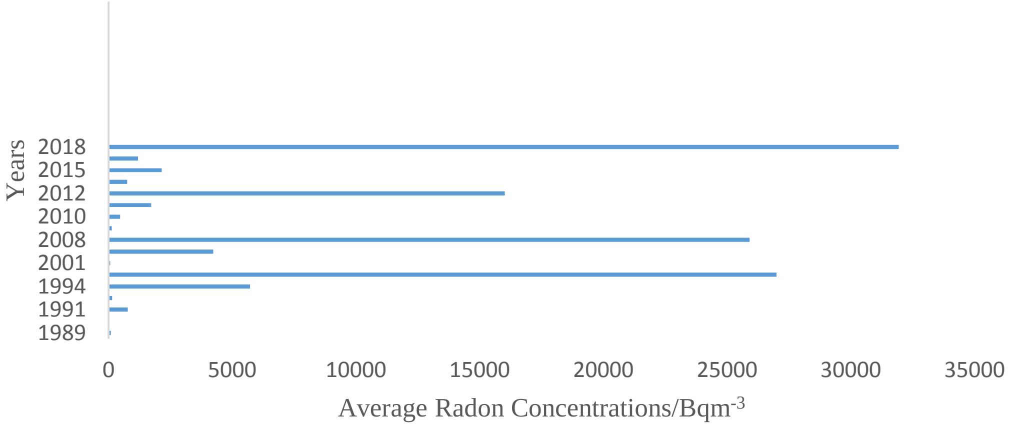

Figure 4.14: Plot of Yearly Average Radon Concentrations

Relating Seismological and Geochemical Assessments

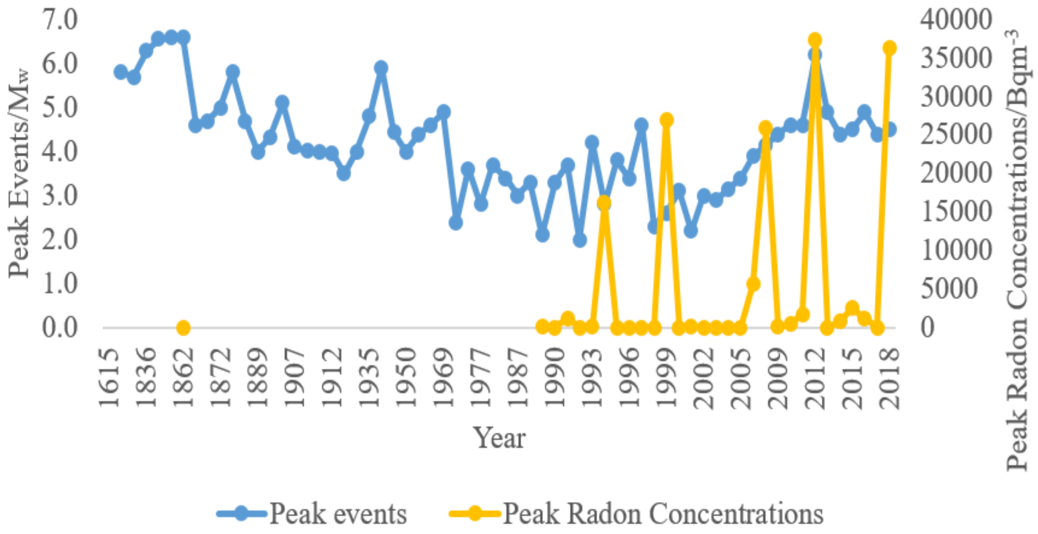

Figure 4.15: Seismicity-Radon Concentration Plot (1836-2018)

From Fig. 4.15 peak values of seismicity started emerging between 1993 and 1996. Major correlations between seismicity and radon can be observed in 2000, between 2005 and 2009, 2012, 2015 and finally in 2018. With this observation the absence of data around 2004 can be assumed to follow the same trend if present.

Pearson's Correlation Coefficient

Pearson's correlation plotted for radon emanation and precipitation are represented in Fig. 4.16.

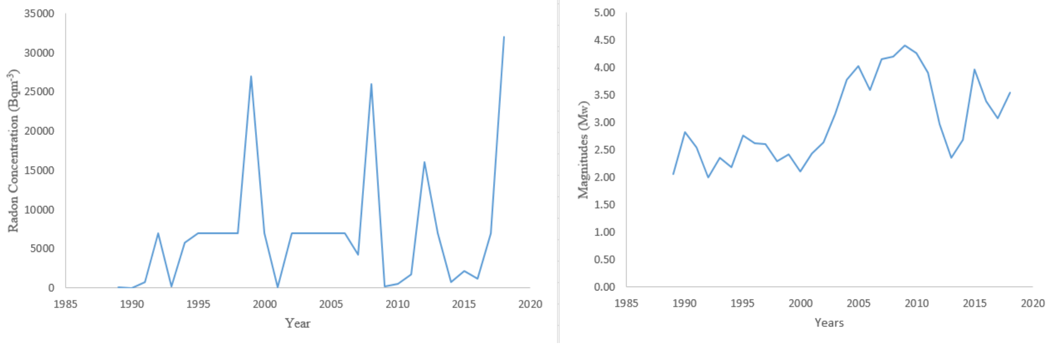

Figure 4.16: Pearson's Correlation Plot (1836-2018)

A Pearson’s correlation is displayed in Fig. 4.16 with an r-value of 0.1 (t-statistic of 0.40 and a p-value of 0.69) exist between isotopic anomaly of interest (radon concentration) and seismicity. Pearson's correlation coefficient here also measures the strength and direction of a linear relationship between the two variables. The p-value, however, is a probability used in statistical hypothesis testing to determine the likelihood that a result occurred by chance (to evaluate the statistical significance). The p-value is calculated based on the sampling distribution of the test statistic (0.4).

A p-value of 0.69 indicates that there is a 69% chance that the observed result occurred by chance. In other words, there is a 31% chance that the observed result is due to a real difference between the groups being compared (Ji et. al., 2006). In the case of this study, disproportionate expansion of faults, fractures and suture zones are most likely to influence a proportionate relationship. This makes the result difficult to be considered as a true positive relationship between seismicity and geochemical anomalies observed. A second likely reason for the miss on the < 0.05 or 5% may be attributed to the absence of radon data from 1994 to 1998. This incompleteness in data can influence obtained p-value results (Bollinger et. al., 2008).

It is important to note that a p-value may not necessarily measure the size of the effect or the strength of the relationship between the seismological and geochemical parameters. It only indicates the likelihood that the observed result occurred by chance (Bollinger et. al., 2008; Chen et. al., 2009).

KOBO and SPSS (Did You Feel It?) Assessment

Fig. 4.17 observes what time the earthquake was experienced. Other analyses include, whether the respondents experienced earthquake in the night or during the day.

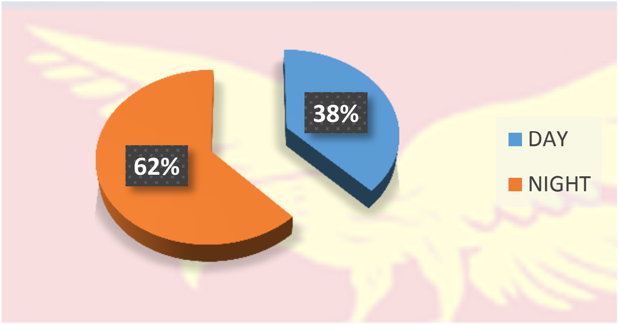

Figure 4.17: Response for Night and Day Experience

Out of the total respondents who participated in the study, all of them experienced earthquake. This implied that the respondents are able to understand the subject under study. Again, 62.3% of the respondents indicated that the earthquake occurred in the night and 37.7% were those that experienced an earthquake in the day time. This showed that majority of the respondents witnessed the earthquake in the night.

Respondents' situation during the earthquake was also studied and the study revealed that 32.6% were not specific about their situation during the earthquake, 31.3% were respondents inside a building during the earthquake, 32.3% and 3.5% were respondents in a vehicle and in a moving car respectively when the earthquake occurred. Others, 31.6% were unable to specify whether they were asleep during the earthquake.

With respect to investigatioin on creaking noise, 22 out of 310 respondents heard creaking noises whilst 78 of them heard slight noise. This could be partly due to the fact that 62% of the events happened at night (Fig. 4.18).

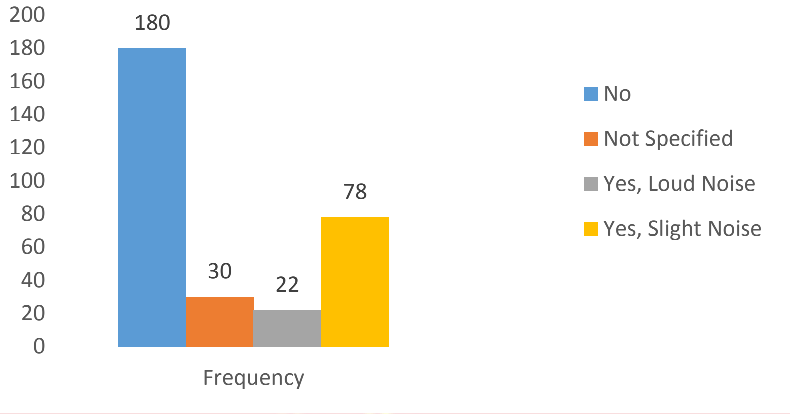

Figure 4.18: Response for Creaking Noise Experience

The data gathered from the respondents indicated that only 12.6% of the respondents' notice swinging of doors or other freely hanging object and 62.6% of the respondents did not notice any swinging of doors. 19.4% of the respondents notice slight swinging of doors or other free hanging objects. Finally, 5.5% of the respondents notice violent swinging of doors.

The nature of the responses indicates that most people within the study area are aware of seismic activities there but they do not fully understand the causes and the degree of retribution that can occur if a higher magnitude one strikes. Details of the questionnaire (coding and responses) and output are in Appendix D.

Chapter Summary

Seismic data were finally settled on after deleting events of magnitude less than 2 M_w. Events from all categories were used, relocated where necessary and interpolated. Events of as high as 4.7 Mw in 2013 and 4.4 Mw in 2018 have been recorded.

From the plot of events from 1615 to 2018, increased seismic activity has been observed. It becomes clearer when 1836 to 2018 is zoomed in on (Fig. 4.1). The b-values evaluated for 1615 to 2015 and 1615 to 2018 by the maximum likelihood estimation method have yielded significant improvement in network stress estimates compared to the linear list square fit model, a conventional averaging technique (Table 4.4). Significant earthquake magnitudes $> 6\ M_w$ have been observed offshore Ghana.

Seismicity and Epicentral Intensity Maps show increasing activity with majority events below 4 M_w. GAMA, the focus of this research, has been observed to be continuously active seismically.

A linear relationship established between seismicity and precipitation with a Pearson's correlation coefficient of 0.4 and p-value of 0.04 calculated. Isotopic anomaly assessments to observe geochemical shifts in activities at the study area also reveal increasing concentration of radon emanation. SSNTD and EPERM analysis revealed increased radon levels in 2018 with a national radon average of 20377 Bqm^{-3} for soil and 4333.33 Bqm^{-3} for water respectively. By area, GAMA has 36321.55Bqm^{-3} reading with the main city centre Accra recording as high as 25920.00Bqm^{-3}. Generally, radon levels are currently almost hitting a record high of almost 40,000Bqm^{-3} in GAMA.

However, a very weak positive Pearson's correlation coefficient of 0.1 and a p-value of 0.69 were calculated for seismicity-radon concentration relationship.

The KOBO and SPSS analysis show that 62% of the respondents indicated that the earthquake occurred in the night and 38% were those that experienced the earthquake in the day time. This showed that majority of the respondents have ever witnessed earthquake in the night. Respondents', 31.6% were unable to specify whether they were asleep during the earthquake or not..

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview

In geohazard assessment, b-value evaluations are used to estimate the stress level of a given geology usually by the Linear Least Square or Maximum Likelihood Estimation Procedure. This is done by generating or relying on a complete earthquake catalogue. This catalogue is then used to create a cumulative frequency table up to the date of b-value evaluation and plotted to produce the equation of a straight line comparable to the Guttenberg-Richter equation to help calculate the stress (b-value).

Surging or dipping seismicity is directly linked to rising or falling precipitation and/or radon levels respectively. This study therefore determined this connection in the study area using, GIS, MATLAB, KOBO and SPSS.

To update the radon chart for GAMA, field works were conducted in Donkunah, Kwanenya, and Weija to establish current trends and establish the relationship with the seismicity of study area.

Summary

A geohazard assessment was done in the GAMA by burying radon detectors in Donkunah, Kwabenya and Weija to update radon chart. Groundwater was also sampled from these locations. Detectors and groundwater sampled gave current high radon concentrations.

The increased seismic activities recorded in GAMA corroborate the observations discussed. Some of these include, increased activity in the Weija Lake, contstant tremors $\geq 3\ M_w$, increased seismicity offshore Ghana, records of magnitude $6\ M_w$ offshore Ghana and b-values of approximately 1. The subsequent identification of increased precipitation resulting even in severe flooding of Accra in the just recent past cannot be overlooked when juxtaposed with time of occurrence. GIS generated maps of seismicity of the study area indicate Weija, Central Accra, Nyanyano, Kokrobite and Tema and their environs to be areas that are very active seismically.

With seismic events (tremors) of over 4 Mw becoming normal, radon concentrations of over 3600 Bqm^{-3} and over 1250 mm precipitation observed, one can safely conclude the three-dimensional direct relationship clearly established.

The average stress value of 0.91 computed by the maximum likelihood estimation method show the unstable nature of the geology of GAMA contrary to earlier held views of fair stability that seek to downplay the effect of below 5 M_w events and the abundance of seismic activities in GAMA. An investigation of correlation between seismics and precipitation by way of meteorological assessement gave a p-value of 0.04 whilst the geochemical-seismological investigation produced a p-value of 0.69.

Healthwise, 100 Bqm^{-3} radon concentration is acceptable in homes whilst a 300 Bqm^{-3} should not be exceeded (WHO, 2020). However, it can be seen that radon concentration records in recent years (Table 4.8) are higher than the recommended standard.

Conclusions

A seismological, meteorological and geochemical investigation for earthquake hazard has been carried out in the Greater Accra Metropolitan Area in Ghana. The following conclusions have been drawn from the results of the assessment.

1. Generally, an improved (updated), unified, harmonized and standardised earthquake catalogue for Ghana has been generated.
2. This catalogue has been depended on to calculate a b-value for the Greater Accra Metropolitan Area.
3. Current seismicity, epicentral-intensity and isoseismal maps for the subregion, Ghana and GAMA have been produced.
4. A relationship has between established between seismicity and precipitation (meteorology), and seismicity and radon emanation (geochemistry) in the GAMA.

By seismological investigation, an updated, unified, harmonized and standardized earthquake catalogue has been used to evaluate the stress level and seismic trends in GAMA by the use of mathematical (statistical) methods.

With more data included, b-value will have been expected to be approximately 1.0. The increase from 0.56 to 0.69 from 2015 to 2018 by LLS and an average of 0.91 by MLE can be attributed to the elasticity in seismicity of GAMA and increasing fracturing in the face of changing climatic conditions.

As observed in the seismological results, Weija, Madina, Nungua, Nyanyano and North eastern Akropong fall within the same isoseismal and can experience earthquakes with an approximate epicentral intensity of VIII (this area is very active seismically as seen in Fig. 4.7, Fig. 4.8 and Fig. 4.9)

The meteorological investigation established a relationship between seismicity and precipitation by identifying a linear correlation between seismicity and precipitation. It is observed that the trend is becoming the norm due to changing climatic conditions resulting in severity in rainfall patterns in southern Ghana. It is therefore believed that recent earthquakes and tremors will keep increasing in number of occurrence and magnitude until a major event occurs and brings some degree of stability.

The geochemical investigation observed rising radon levels in Kwabenya, Donkunah and Weija. The link between radon concentration levels in the year 2000, 2005, 2009, 2012, 2015 and 2018 shows that the availability of data for earlier years would have recorded a better p-value than 0.69 obtained. The geochemical investigation however, helps to validate the results of the seismological and meteorological assessments and concludes that there's stress build up in the study area and makes recommendations based on this assertion.

Recommendations

The investigations carried out outline the following recommendations.

For Further Studies

1. A software must be developed to keep people alert on geohazard (seismicity) in real time using a built-in time series algorithm.
2. The sudden surge in radon concentration recorded in the study area must be continually monitored since it has been proven to have a direct relationship with seismic events. This can help mitigate geohazards in GAMA.

To Organizations

1. The government must support the Ghana Geological Survey Authority to help fix broken down seismographs on time. This will help record more events to aid completeness of subsequent catalogues needed for research.

2. Further collaborative research is needed between the Ghana Geological Survey Authority's Seismological Observatory, Ghana Atomic Energy Commission and the Ghana Meteorological Agency to see the consistency in the correlation between precipitation and seismicity.
3. Those around the Weija dam must be relocated since the area is a very active zone in terms of seismic activity; a high magnitude earthquake is imminent (looking at the current seismic trends). The local authority and NADMO must see to this.

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APPENDICES

APPENDIX A

EARTHQUAKE CATALOGUE OF GHANA AND ITS IMMEDIATE NEIGHBOURS (2015-2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Locations
1615						5.1	-1.3		5.2	8			AMB	Elmina,Ghana
1636	12	18	14			5.1	-2.2		5.8	9			AMB	Axim, Fort Duma, Ghana
1788						7.6	1.7		5.7	8			AMB	Agunah/Togo
1836	12					5.1	-1.3		6.3	6.5			AMB	Cape Coast, Ghana
1858						5.6	-0.2		6.6	6			AMB	Accra, Ghana
1861						6	0		6.6	5			AMB	Akropong Akwapim
1862	7	10	8	15		7	0.4		6.6	9	700		AMB	Kpando, Ghana
1870	11	23	12			5.3	-0.7		4.6	5			AMB	Apam, Ghana
1871	1	26	20			5.5	-0.4		4.7	6			AMB	Accra, Ghana
1872	4	14	23			5.5	-0.4		5.0	7			AMB	Accra, Ghana
1879	2	11	6			6.5	-3.3		5.8	8	380		AMB	Abidjan-Cote d'Ivoire
1883	8	13	2	30		5.5	-0.4		4.7	6	150		AMB	Accra, Ghana
1889	4	5	12	20		5.9	-0.2		4.0	4			AMB	Amanokrom, Ghana
1894						5.5	-0.2		4.3	3.5			AMB	Accra, Ghana
1906	11	20	21	0		6.5	0.3	12	5.1	7.5	250		ALY	Near Ho-Ghana
1907	2	27	22	15		6.1	-0.9		4.1	4			AMB	Kade, Ghana
1910	12	25				5.6	-0.2		4.0	5			AMB	Accra, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
1912						5.5	-3.6		4.0	4			AMB	Alepe, Cote d'Ivoire
1930	10	14				7.1	0.7		3.5	4			AMB	Kpalime, Agu-Togo
1933	1	6	4			7	0.6		4.0	6	100		AMB	Kpalime, Misahoe-Togo
1935	5	29				6.9	0.6		4.8	6			AMB	Near Kpalime, Togo
1939	6	22	19	19	26	5.4	-0.25	18	6.4	8	680		ALY	Coast of Accra, Ghana
1939	8	18	4	51	14	6.2	-0.3		5.4	6			AMB	Koforidua, Ghana
1948						6.2	0.4		4.4	4			AMB	Atimpoku, Ghana
1950	4	4	22	9		6.8	-4.6		4.0	4			AMB	Dimbroko-Cote d'Ivoire
1950	10	20	15	21	45	7.5	0.5		4.0	4			AMB	Kadjebi-Togo
1964	3	11	12	45	56	5.9	-0.39		4.4	6			AMB	Amasaman, Ghana
1966						5.58	-0.35		4.6	4	10		ALY	Weija, Ghana
1969	2	9	18	29	4	5.5	-0.2	17	4.9	5.5	190		ALY	Accra, Ghana
1973	8	23	17	15		5.7	0.3		2.4				GSD	Offshore-Lepongune
1973	11	28	11	33	21	7	0.8		1.9				GSD	Forêt du Mont Haito, Togo
1974	1	11	5	29	52	5	-2.6		3.6				GSD	Beku, Western Ghana
1974	1	16	17	8	50	6.5	0.5		1.9				GSD	Near Tsrefe-Ghana
1974	2	20	3	13	43	5	-2.6		3.1				GSD	Beku, Western Ghana
1974	6	2	23	15	9	5.8	0.8		2.6				GSD	Jogbove, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
1974	6	8	15	3	5	5.1	2.5		3.4				GSD	Togo
1977	2	2	2	56		5.77	-0.2		2.0				GSD	Pokuase, Ghana
1977	2	25	1	19		6.02	-0.2		2.5				GSD	Gulf of Guinea, Togo
1977	3	1	20	50		5.72	-0.2		2.7				GSD	Pokuase, Ghana
1977	3	1	20	58		5.58	-0.28		1.9				GSD	Oblogo, Ghana
1977	4	2	16	11		6.23	-0.13		2.1				GSD	Senchi, Ghana
1977	4	15	23	46		5.95	-0.07		2.4				GSD	Akropong, Ghana
1977	4	29	18	23		5.67	-0.2		2.5				GSD	Pokuase, Ghana
1977	6	18	4	17		5.63	0.02		2.1				GSD	Prampram, Ghana
1977	7	20	19	34		5.65	-0.28		2.0				GSD	Pokuase, Ghana
1977	7	26	9	15		5.57	-0.38		2.4				GSD	Weija, Ghana
1977	10	8	3	15		5.97	-0.03		2.8				GSD	Adukrom, Ghana
1977	11	18	23	11		5.58	-0.38		2.2				GSD	Weija, Ghana
1977	11	23	22	9		6	0.12		2.0				GSD	Agomeda, Ghana
1978	2	7	1	44		6.58	0.13		2.8				GSD	Peki, Ghana
1978	3	3	5	35		5.53	-0.38		3.0				GSD	Ngleshi Amanfro, Ghana
1978	7	6	18	10		6.6	0.27		2.0				GSD	Near Adzokoe, Ghana
1978	9	5	22	59	30	5.63	-0.35		3.7	4			AMB	Weija, Ghana
1978	9	6	12	39		5.63	-0.35		2.1				GSD	Weija, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
1978	9	21	1	22		5.53	-0.4		1.9				GSD	Nyanyanu, Ghana
1978	12	2	11	10		5.53	-0.37		1.9				GSD	Kokrobite, Ghana
1979	1	9	13	58	53	5.58	-0.32		3.4	3.5			AMB	Oblogo, Ghana
1979	1	25	9	0		5.5	-0.33		2.2				GSD	Kasoa, Ghana
1979	3	9	20	16		5.57	-0.38		2.2				GSD	Weija, Ghana
1979	3	15	17	37		5.52	-0.35		2.3				GSD	Botianor, Ghana
1979	6	18	18	51		5.5	-0.42		1.9				GSD	Odupomkpehe, Ghana
1979	6	27	20	26		5.53	-0.43		2.1				GSD	Obutu, Ghana
1979	6	28	21	54		5.77	-0.28		1.9				GSD	Doboro, Ghana
1987	7	7	8	11	56	5.44	-0.4		2.7				GSD	Offshore-Nyanyanu
1987	7	31	23	52	4	5.67	-0.26		1.9				GSD	Pokuase, Ghana
1987	11	5	0	0	18	5.58	-0.32		2.5				GSD	Weija, Ghana
1987	12	3	0	29	48	5.51	-0.26		3.0				GSD	Offshore-Labadi, Ghana
1987	12	3	10	37	38	5.53	-0.41		3.0				GSD	Obutu, Ghana
1988	2	27	0	51	4	5.5	-0.4		3.2				GSD	Kasoa, Ghana
1988	3	6	12	15	8	5.63	-0.27		1.9				GSD	Pokuase, Ghana
1988	3	20	19	9	50	5.56	-0.3		1.9				GSD	Oblogo, Ghana
1988	3	25	1	0	35	5.6	-0.28		2.0				GSD	Weija, Ghana
1988	3	29	16	54	4	5.6	-0.11		3.3	4			ISC	Legon-Accra, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
1988	4	24	13	18	46	5.61	-0.31		1.9				GSD	Kwashiman, Ghana
1988	5	6	1	48	43	5.6	-0.32		2.1				GSD	Oblogo, Ghana
1988	5	31	7	35	8	5.45	-0.37		2.3				GSD	Offshore-Nyanyanu
1988	12	5	5	12	43	5.48	-0.4		2.4				GSD	Offshore-Nyanyanu
1989	3	23	13	32	47	5.59	-0.33		1.9				GSD	Kwashiman, Ghana
1989	6	27	18	28	9	5.31	-0.6		2.1				ISC	Offshore-Winneba
1990	2	12	1	34	41	5.61	-0.34		2.6				NEI	Weija, Ghana
1990	4	14	11	43	26	5.59	-0.34		2.9	3			GSD	Weija, Ghana
1990	9	15	9	32	1	5.4	-0.55		3.3				GSD	Offshore-Winneba
1990	12	2	0	23	21	5.44	-0.41		2.6				GSD	Offshore-Winneba
1991	1	1	7	58	8	5.93	-0.12		2.3				GSD	Akropong, Ghana
1991	3	6	14	54	33	5.61	-0.3		2.1				GSD	Weija, Ghana
1991	3	6	16	50	33	5.62	-0.31		2.3				GSD	Weija, Ghana
1991	3	27	22	18	2	5.64	-0.29		2.9				GSD	Weija, Ghana
1991	6	30	20	44	18	5.62	-0.35		2.3				GSD	Weija, Ghana
1991	8	23	9	51	6	5.62	-0.33		3.7				GSD	Weija, Ghana
1991	10	23	0	14	12	5.53	-0.35		2.3				GSD	Weija, Ghana
1992	3	29	20	2	23	5.62	-0.33		2.0				GSD	Achimota, Ghana
1993	4	3	22	33	10	5.5	-0.27		2.1				GSD	Offshore-Nyanyanu

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
1993	4	6	14	29	38	1.3	1.62		4.2				ISC	Gulf of Guinea, near Benin
1993	5	7	1	40	46	5.53	-0.23		2.3				GSD	Offshore-Botianor, Ghana
1993	6	22	14	55	39	5.63	-0.56		2.3				GSD	Obrachere, Ghana
1993	6	27	3	38	23	5.53	-0.27		2.7				GSD	Botianor, Ghana
1993	6	28	5	49	3	5.59	-0.32		2.4				GSD	Weija, Ghana
1993	7	17	15	59	59	4.05	-2.44		2.7				ISC	Gulf of Guinea
1993	9	8	3	52	39	5.52	-0.34		2.1				GSD	Offshore-Nyanyanu
1993	10	7	18	17	10	5.55	-0.36		2.3				GSD	Weija, Ghana
1993	10	28	10	8	2	5.5	-0.34		2.1				GSD	Offshore-Nyanyanu
1994	1	15	19	51	41	5.38	-0.34		2.5				GSD	Nyanyanu, Ghana
1994	1	17	5	49	27	5.47	0.55		2.3				GSD	Brofo Yeduro, Ghana
1994	1	27	18	28	1	5.6	-0.27		2.4				GSD	Offshore-Botianor, Ghana
1994	8	26	12	48	20	5.47	-0.27		2.0				GSD	Botianor, Ghana
1994	8	28	9	44	25	5.36	-0.32		1.9				GSD	Nyanyanu, Ghana
1994	9	6	1	1	4	5.52	-0.37		2.3				GSD	Odupomkpehe, Ghana
1994	9	6	17	30	54	7.65	-3.48		2.8				ISC	Cote d'Ivoire, Ghana
1994	9	6	17	32	8	5.53	-0.42		2.0				GSD	Obutu, Ghana
1994	10	22	12	4	2	5.6	-0.4		1.9				GSD	Nyanyanu, Ghana
1994	11	10	9	38	3	5.54	-0.35		2.3				GSD	Oblogo, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
1994	12	7	1	21	7	5.52	-0.25		2.0				GSD	Odupomkpehe, Ghana
1995	1	27	19	16	16	5.45	-0.3		2.2				GSD	Offshore-Botianor, Gh
1995	1	28	20	22	0	5.6	-0.28		2.3				GSD	Botianor, Ghana
1995	1	28	20	33	14	5.6	-0.36		2.3				GSD	Oblogo, Ghana
1995	1	28	20	37	10	5.53	-0.32		3.1				GSD	Kokrobite, Ghana
1995	1	28	20	39	14	5.55	-0.4		3.2	3			GSD	Weija, Ghana
1995	2	1	3	44	17	5.63	-0.57		2.5				GSD	Obrachere, Ghana
1995	2	1	3	45	20	5.63	-0.45		3.6				GSD	Obrachere, Ghana
1995	2	1	3	58	39	5.6	-0.32		2.6				GSD	Oblogo, Ghana
1995	3	9	18	55	18	5.58	-0.33		3.2	3			GSD	Weija, Ghana
1995	5	3	19	34	1	5.55	-0.3		2.5				GSD	Oblogo, Ghana
1995	6	27	23	43	0	5.52	-0.26		2.4				GSD	Offshore-Botianor
1995	10	12	1	8	35	5.5	-0.24		2.5				GSD	Offshore-Botianor
1995	10	27	20	1	33	5.5	-0.35		3.8				GSD	Offshore-Kokrobite
1996	2	21	21	29	15	5.57	0.06		2.2				GSD	Offshore-Teshie
1996	2	22	9	14	39	5.58	-0.45		3.4				GSD	Teshie, Ghana
1996	2	23	9	15	7	5.28	-1.42		2.8				ISC	Komenda, Ghana
1996	7	5	7	42	36	5.43	-0.34		3.0				GSD	Offshore-Botianor
1996	8	2	22	37	26	5.44	-0.48		2.4				GSD	Fete, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
1996	8	2	9	26	32	5.44	-0.47		2.3				GSD	Fete, Ghana
1996	8	2	21	1	18	5.52	-0.49		2.4				GSD	Obutu, Ghana
1996	8	31	3	4	59	5.44	-0.43		2.9				GSD	Offshore-Fete, Ghana
1996	9	12	15	15	23	5.62	-0.27		2.3				GSD	Pokuase, Ghana
1996	9	21	18	1	42	5.47	-0.27		2.4				GSD	Offshore-Botianor
1996	10	8	12	1	36	5.67	-0.32		2.2				GSD	Manhea, Ghana
1996	10	21	14	19	10	5.82	-0.35		3.2				GSD	Nsawam, Ghana
1997	1	8	9	35	37	5.63	-0.34		2.1				GSD	Weija, Ghana
1997	2	14	23	26	7	5.66	-0.43		2.6				GSD	Dantsera, Ghana
1997	2	14	23	29	5	5.67	-0.4		3.9	4.5			GSD	Manhea, Ghana
1997	3	6	15	16	38	5.6	-0.33		4.6	5.5			GSD	Weija, Ghana
1997	3	6	15	59	36	5.6	-0.38		2.2				GSD	Manhea, Ghana
1997	3	6	16	17	0	5.65	-0.38		1.9				GSD	Manhea, Ghana
1997	3	13	18	54	52	5.65	-0.34		2.2				GSD	Weija, Ghana
1997	3	13	0	55	35	5.62	-0.34		2.0				GSD	Weija, Ghana
1997	3	27	14	29	5	5.62	-0.34		2.3				GSD	Weija, Ghana
1997	9	24	3	2	3	5.6	-0.33		2.3				GSD	Weija, Ghana
1998	1	27	14	4	42	5.75	0.01		2.0				AMP	Katamanso, Ghana
1998	11	19	0	5	2	5.72	0.28		2.0				AMP	Offshore-Old Ningo

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
1998	11	25	21	14	10	5.77	0.18		2.3				AMP	Offshore-Gulf of Guinea
1998	12	23	16	15	23	5.25	-0.22		2.0				AMP	Offshore-Nyanyanu, Ghana
1999	1	20	4	53	34	5.35	0		2.2				AMP	Offshore-Tema, Ghana
1999	5	19	15	11	43	5.79	-0.25		2.5				AMP	Abokobi, Ghana
1999	8	22	23	35	29	6.1	-1.29		2.6				AMP	Ochereso, Ghana
1999	10	30	10	21	39	5.79	0.29		2.4				AMP	Offshore-Old Ningo, Ghana
2000	1	30	14	58	19	5.3	-0.32		2.3				AMP	Offshore-Labadi, Ghana
2000	4	17	6	29	23	6.59	0.48		2.1				AMP	Akuse, Ghana
2000	6	8	21	38	38	5.32	-0.01		2.3				AMP	Labadi, Ghana
2000	7	9	20	39	28	5.48	-0.14		2.1				AMP	Aburi, Ghana
2000	8	14	0	2	42	5.78	-0.15		2.5				AMP	Oyarifa, Ghana
2000	9	2	18	27	11	5.59	-0.86		2.2				AMP	Odoben, Ghana
2000	11	8	8	18	29	5.66	2.6		2.6				AMP	Offshore-Prampram, Ghana
2000	11	26	10	26	32	5.54	0.13		3.1				AMP	Offshore-Tema, Ghana
2000	12	8	21	18	45	5.83	-0.24		2.7				AMP	Aburi, Ghana
2001	9	22	8	58	34	5.56	0.18		2.2				AMP	Offshore-Kpong, Ghana
2002	1	24	22	8	23	5.75	0.85		2.6				AMP	Offshore-Ada, Ghana
2002	2	21	6	28	35	5.6	0.13		2.7				AMP	Offshore-Tema, Ghana
2002	2	22	2	14	34	5.4	-0.5		2.8				AMP	Senya-Breku, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2002	5	17	13	37	11	5.6	0.1		2.2				AMP	Offshore-Tuba, Ghana
2002	6	7	1	31	22	5.65	-0.27		2.3				AMP	Oblogo, Ghana
2002	6	7	1	35	40	5.5	-0.3		3.0				AMP	Offshore-Botianor, Ghana
2002	11	27	5	32	27	5.55	0.5		2.0				AMP	Offshore-Tema, Ghana
2002	11	29	16	43	43	5.25	-0.6		2.0				AMP	Offshore-Winneba, Ghana
2003	5	18	6	51	16	5.57	-0.32		2.9				AMP	Weija, Ghana
2003	5	18	7	2	14	5.58	-0.32		2.2				AMP	Weija, Ghana
2003	5	18	13	18	24	5.57	-0.38		2.6				AMP	Weija, Ghana
2003	6	22	6	8	10	6.7	-1.9	2	2.9			86	ISC	Kumasi-Sunyani Road, Ghana
2004	4	17	13	21	13	5.3	-2.6	2	3.2			115	ISC	Elubo-Enchi Road, Ghana
2004	7	2	9	30	33	7.4	-7.1	2	3.2			114	ISC	Man-Cote d'Ivoire
2005	9	29	16	39	18	3.7	-6.3	2	3.4			26	ISC	NAO-Near Cote d'Ivoire
2007	3	6	0	4	25	5.7	-6.9	50	3.9			68	ISC	Tai National Park, Cote d'lvoire
2008	6	9	21	48	51	4.6	-3.9	50	4.2			150	ISC	Gulf of Guinea, Cote d'Ivoire
2008	6	26	4	51	42	6.2	-4.7	20	4.2			140	ISC	Tiassale-Cote d'Ivoire
2008	8	16	11	31	49	9.2	-1.5	30	4.2			100	ISC	Daboya-Busunu Road, Ghana
2009	9	11	3	10	19	6.7	2.2	10	4.4			165	ISC	Cotonou-Porto-Novo area, Benin
2009	10	23	10	31	35	9.4	-2.4	30	4.4			41	ISC	Near Mole National Park, Ghana
2009	12	12	18	8	6	7.0	-1.9	2	4.4			80	ISC	Near Kumasi, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2010	9	30	5	53	31.45	7.3	-2.1		4.4			142	NDC	Nkinkanso, Ghana
2010	10	3	16	15	39.31	11.8	0.1		2.4			138	NDC	Saltenga, Burkina Faso
2010	10	3	22	38	23.41	6.4	-6.2		4.1			157	NDC	Guguha, Cote d'Ivoire
2010	10	7	13	27	55.11	5.4	-3.1		2.7			8	NDC	Mafere, Abidjan, Cote d'Ivoire
2010	10	30	1	40	31.7	5.6	-5.8		4.0			139	NDC	Gogue, Cote d'Ivoire
2010	11	4	1	12	38.13	6.7	-4.9		4.1			154	NDC	Dimbokro, Cote D'Ivoire
2010	11	4	15	41	15.38	11.8	1.0		4.2			107	NDC	Alondigwena, Burkina Faso
2010	11	7	3	4	49.12	10.7	0.0		3.9			124	NDC	Dore, Northern Togo
2010	11	10	3	24	24.44	7.1	-6.1		4.2			20	NDC	Bafla, Cote D'ivoire
2010	11	10	3	56	32.03	1.1	-3.1		4.3			173	NDC	Near coast of Ghana / Cote D'Ivoire
2010	11	14	8	8	36.25	6.7	-4.5		4.0			121	NDC	Banngokro, Cote D'voire
2010	11	17	22	33	42.48	-7.5	-13.3		4.6			104	NDC	in the South Atlantic ocean
2010	11	20	5	11	59.15	8.7	-4.6		4.1			110	NDC	Kapolokoro, Cote D'Ivoire
2010	11	21	2	52	46.99	11.8	3.1		4.3			19	NDC	Boiffo, Benin
2010	11	22	7	22	20.93	7.3	-4.3		4.4			128	NDC	Angoakro, Cote D'Ivoire
2010	11	22	9	25	59.82	6.8	-7.6		3.9			25	NDC	Moyen-Cavally, Cote D'Ivoire
2010	11	25	5	42	4.59	6.2	-6.0		2.8			159	NDC	Fromager, Barouyo, Cote D'Ivoire
2010	11	26	21	1	6.94	5.3	-2.4		3.8			19	NDC	Kwesikrom, Ghana
2010	11	26	23	59	56.07	12.0	0.9		4.1			117	NDC	Boumwana, Burkina Faso

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2010	11	30	4	49	33.64	6.7	-4.4		4.1			110	NDC	Aoussoukro, Cote D'Ivoire
2010	11	30	20	42	34.93	5.8	-4.9		4.3			100	NDC	Su-Bandama, Guiguedou
2010	12	1	16	5	44.72	7.3	-6.1		4.2			8	NDC	Marahou, Zeizra, Cote D'Ivoire
2010	12	2	11	8	48.66	14.2	0.3		4.3			59	NDC	Arbinda, Burkina Faso
2010	12	3	13	22	56.26	12.7	1.0		4.1			159	NDC	Foadyendyengou, Burkina Faso
2010	12	3	15	34	11.82	7.8	-5.6		4.1			112	NDC	Vallee du Bandama, Cote D'Ivoire
2010	12	4	17	3	29.08	13.6	0.5		2.3			18	NDC	Sahel, Burkina Faso
2010	12	5	1	7	29.27	12.7	0.4		4.0			48	NDC	Louauga, Burkina Faso
2010	12	6	4	49	41.01	7.7	-3.9		3.8			125	NDC	Nzi-Commoe, Cote D'Ivoire
2010	12	7	4	37	4.47	6.7	-4.4		3.9			97	NDC	Aoussoukro, Cote D'Ivoire
2010	12	9	4	10	6.26	6.5	-5.3		4.1			84	NDC	Fromager, Cote D'Ivoire
2010	12	11	4	59	17.66	6.5	-5.1		4.2			145	NDC	Lacs, Cote D'Ivoire
2010	12	12	18	11	44.21	10.6	-3.1		3.8			74	NDC	Sud-Ouest, Nako, Burkina Faso
2010	12	17	5	56	31.17	6.7	-4.8		4.2			12	NDC	Dimbokro, Cote D'Ivoire
2010	12	22	4	3	43.48	-4.8	-11.8		4.3			141	NDC	Coast of Liberia / Cote D'Ivoire
2010	12	22	4	6	37.05	5.8	-5.1		4.6			124	NDC	Ble, Cote D'Ivoire
2010	12	29	7	12	58.47	1.7	-3.2		4.3			144	NDC	near coast of Ghana / Cote d'Ivoire
2010	12	29	12	42	32.37	12.2	0.6		4.0			133	NDC	Koulmyougou, Burkina Faso
2010	12	31	10	18	38.13	5.7	-4.4		4.1			82	NDC	Yaobam, Cote d'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2011	1	7	20	48	41.71	10.1	-2.8		4.1			109	NDC	Bopiel, Burkina Faso
2011	1	9	10	24	48.64	-1.2	-18.0		4.3			136	NDC	the coast of West Africa
2011	1	10	2	29	59.1	-0.5	-5.4		4.2			93	NDC	off the coast of Abidjan, Cote d'ivoire
2011	1	11	15	41	42.68	-8.4	-5.2		4.3			92	NDC	South Atlantic Ocean, Ghana
2011	1	14	12	56	43.87	3.7	-5.4		4.4			90	NDC	near coast of Abidjan, Cote d'Ivoire
2011	1	15	3	18	43.86	12.2	-1.1		4.2			3	NDC	Plateau - Central Region, B. Faso
2011	1	15	10	51	0.96	5.8	-6.0		4.1			147	NDC	Seryo, Cote d'Ivoire
2011	1	17	2	3	38.94	11.8	2.0		4.2			127	NDC	Logbobou, Burkina Faso
2011	1	17	19	0	29.82	-5.5	-4.5		4.3			131	NDC	south atlantic ocean, near cote divoire
2011	1	21	19	4	6.19	6.2	-6.1		4.0			167	NDC	Menekie, Cote d'Ivoire
2011	1	26	15	43	58.1	6.1	-6.0		3.9			157	NDC	Bogrenyoa, Cote d'Ivoire
2011	1	26	17	35	18.57	6.6	-4.8		4.1			131	NDC	Assebrakro, Cote d'lvoire
2011	1	26	23	9	59.14	5.3	-4.7		4.3			179	NDC	baiede Cosron, Cote d'Ivoire
2011	1	27	5	28	7.3	6.7	-4.8		4.3			145	NDC	Assebrakro , Cote d'Ivoire
2011	1	27	10	54	46.54	8.0	-4.5		4.1			110	NDC	Vallee du Bandama, Cote d'Ivoire
2011	1	28	8	19	30.55	6.7	-2.2		2.2			159	NDC	Akantanso, Ashanti Region, Ghana
2011	1	30	14	3	54.04	5.3	-4.7		4.2			72	NDC	Baie de Cosrou, Cote d'Ivoire
2011	1	31	1	57	51.28	1.4	0.3		4.2			62	NDC	south atlantic ocean, near ghana.
2011	1	31	3	13	23.99	6.4	-4.6		4.0			141	NDC	Menou, Cote d'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2011	1	31	15	33	7.21	4.9	-1.6		3.8			123	NDC	Anoe, Sekondi Takoradi, Ghana
2011	2	3	6	1	5.72	0.0	1.6		4.1			100	NDC	Coast of Ghana / Togo
2011	2	3	8	4	52.7	11.9	-4.4		2.3			132	NDC	Kouka, Burkina Faso
2011	2	10	19	10	59.31	7.3	-3.6		3.7			144	NDC	Komoe-Denou, Cote d'Ivoire
2011	2	12	17	59	58.76	12.5	1.2		4.3			133	NDC	Boulmomgo, Burkina Faso
2011	2	16	20	16	14.74	6.1	-6.1		3.3			158	NDC	Bakeyo, Cote d'Ivoire
2011	2	16	23	34	37.64	7.4	-3.6		4.2			142	NDC	Katimasso, Cote d'Ivoire
2011	2	17	0	17	33.89	5.7	-5.8		3.7			143	NDC	Gague, Cote d'Ivoire
2011	2	17	6	26	29.86	6.7	-4.8		4.2			148	NDC	Bofrebo, Cote d'Ivoire
2011	2	17	13	40	20.78	6.8	-6.3		4.0			158	NDC	Bebouo, Cote d'Ivoire
2011	2	19	9	22	49.37	5.8	-5.4		4.5			141	NDC	Divo, Cote d'Ivoire
2011	2	23	17	50	37.19	4.3	-5.0		4.2			117	NDC	nera the coast of Abidjan, Cote d'Ivoire
2011	2	23	19	4	15.46	6.2	-6.1		3.7			158	NDC	Bodounyoa, Cote d'Ivoire
2011	2	24	8	40	11.74	3.0	-3.3		4.4			53	NDC	near the coast of Abidjan, Cote d'Ivoire
2011	2	28	18	39	14.13	5.9	-1.8		4.1			172	NDC	Buabenso, Central Region, Ghana
2011	3	1	00	47	9.55	6.8	-4.7		4.2			54	NDC	Koffi Aoussoukro, Cote D'Ivoire
2011	3	01	02	01	4.73	-5.4	-10.9		4.1			127	NDC	off the coast of Liberia / Cote D'Ivoire
2011	3	01	03	46	29.91	-5.5	-11.1		4.3			142	NDC	off the coast of Liberia / Cote D'Ivoire
2011	3	01	12	32	2.02	5.3	-5.0		4.2			105	NDC	Tiebiessou, Cote D'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2011	3	02	13	09	31.95	5.7	-5.9		4.5			173	NDC	Solouriberipalehoin, Cote D'Ivoire
2011	3	07	00	35	3.37	-8.3	-2.6		3.9			51	NDC	Coast of Cote D'Ivoire / Ghana
2011	3	08	13	37	28.52	5.4	-5.3		4.3			116	NDC	Niakro, Cote D'Ivoire
2011	3	09	04	53	54.31	8.1	-4.9		4.2			55	NDC	Tinbokoro, Cote D'Ivoire
2011	3	09	05	45	40.52	6.9	1.2		4.2			122	NDC	Kpele, Togo
2011	3	10	13	52	13.60	1.1	1.3		4.0			104	NDC	Near the coast of Ghana / Togo
2011	3	10	17	45	49.75	6.2	-5.7		3.9			146	NDC	Laouda, Cote D'Ivoire
2011	3	12	05	54	21.62	3.7	-3.4		4.3			102	NDC	near coast of Abidjan, Cote D'Ivoire
2011	3	13	23	16	7.57	4.8	-5.4		4.2			114	NDC	Ccoast of Abidjan, Cote D'Ivoire
2011	3	14	09	31	24.29	6.8	-4.9		4.2			154	NDC	Tokre-Yoakro, Cote D'Ivoire
2011	3	16	09	58	17.23	6.0	-3.3		4,3			146	NDC	Ebikokorekrou, Cote D'Ivoire
2011	3	16	13	18	29.11	6.2	-3.5		4.0			3	NDC	Mbasso, Cote D'Ivoire
2011	3	18	04	32	52.98	5.6	-4.0		3.9			55	NDC	Brou Asse, Cote D'Ivoire
2011	3	18	17	12	40.26	12.7	-3.7		3.7			9	NDC	Biss, Burkina Faso
2011	3	19	11	34	6.39	12.6	0.9		4.2			150	NDC	Nyamanga, Burkina Faso
2011	3	21	16	20	32.21	5.3	-4.2		4.4			71	NDC	Songon-M'bratte, Cote D'Ivoire
2011	3	22	13	34	28.95	5.3	-5.5		4.2			113	NDC	Mokta, Cote D'Ivoire
2011	3	22	13	40	2.49	12.4	0.9		4.5			24	NDC	Kankantiana, Burkina Faso
2011	3	22	16	52	6.66	3.2	-0.7		2.9			64	NDC	Nnear the coast of Sekondi, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2011	3	23	08	16	46.92	8.4	-6.4		2.0			62	NDC	Kasatou, Cote D'Ivoire
2011	3	24	07	07	31.79	8.4	-5.4		3.9			70	NDC	Kafine, Cote D'Ivoire
2011	3	26	02	16	36.34	6.6	-4.9		3.8			34	NDC	Dimbokro, Cote D'Ivoire
2011	3	26	04	06	48.21	6.4	-5.1		4.2			123	NDC	Bringakro, Cote D'Ivoire
2011	3	27	08	21	30.69	7.2	-3.1		4.2			151	NDC	Kokomia, Cote D'Ivoire
2011	3	29	16	56	8.87	8.6	-2.3		4.3			120	NDC	Tinga, Northern Region, Ghana
2011	4	1	10	25	11.56	6.7	-4.8		4.0			88	NDC	Bofrbo, Cote d'Ivoire
2011	4	1	16	46	27.96	11.9	0.2		3.8			128	NDC	Kouare, Burkina Faso
2011	4	2	4	1	24.78	6.5	-4.6		4.0			108	NDC	Bofrebo, Cote d'Ivoire
2011	4	2	6	46	19.72	7.0	-2.5		4.2			171	NDC	Mim, Brong Ahafo Region, Ghana
2011	4	2	23	2	41.55	5.9	-5.9		4.1			142	NDC	Niali-Gribouo, Cote d'Ivoire
2011	4	3	14	29	32.08	10.0	0.0		4.2			45	NDC	Nagale, Northern Region, Ghana
2011	4	3	17	23	7.82	-9.5	-2.7		4.3			116	NDC	south atlantic ocean, near ghana.
2011	4	3	22	44	43.95	6.5	0.7		3.8			137	NDC	Agotime Kpetoe, Ghana
2011	4	4	2	17	20.5	6.1	-6.2		4.4			180	NDC	Kripayo, Cote d'Ivoire
2011	4	7	5	20	49.58	4.1	-5.0		4.0			119	NDC	near the coast of Abidjan, Cote d'Ivoire
2011	4	8	21	26	57.97	6.6	-4.6		4.4			124	NDC	Frondobo, Cote d'Ivire
2011	4	10	20	6	40.66	6.3	-3.7		3.9			14	NDC	Ananguie, Cote d'Ivoire
2011	4	14	5	32	52.34	16.2	-6.3		3.9			31	NDC	Natabouanga, Burkina Faso

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2011	4	14	13	55	18.82	12.5	0.5		4.0			150	NDC	Natabouanga, Burkina Faso
2011	4	16	14	6	31.37	6.7	-4.9		2.4			133	NDC	Angouakoukro, Cote d'Ivoire
2011	4	17	9	46	36.76	13.0	1.4		4.1			168	NDC	Dimbokro, Cote d'Ivoire
2011	4	17	11	45	15.93	7.0	-4.8		3.9			3	NDC	Angouakoukro, Cote d'Ivoire
2011	4	18	14	13	18.97	6.0	-5.2		4.3			100	NDC	Zehiri, Cote d'Ivoire
2011	4	19	18	34	59.37	5.3	-4.4		4.3			70	NDC	Dabou, Cote d'Ivoire
2011	4	20	0	37	18.21	7.5	-5.0		4.0			83	NDC	Kouabo, Cote d'Ivoire
2011	4	23	11	36	28.61	5.4	-5.4		4.3			133	NDC	Niakro, Cote d'Ivoire
2011	4	25	9	9	38.33	6.8	-5.5		4.3			176	NDC	Boanfla, Cote d'Ivoire
2011	4	25	22	36	55.68	10.3	-0.6		2.2			134	NDC	Bazai, Cote d'Ivoire
2011	4	26	22	2	45.6	6.7	-4.8		3.8			59	NDC	Angouakoukro, Cote d'Ivoire
2011	5	06	20	07	38.97	1.1	-5.9		3.9			89	NDC	gulf of guinea, near cote d'ivoire
2011	5	07	01	49	34.79	6.0	-3.8		4.0			28	NDC	adzope, cote d'ivoire
2011	5	07	17	27	32.32	7.6	1.1		3.7			114	NDC	Plateaux, Togo
2011	5	09	06	27	22.32	12.8	1.3		4.2			140	NDC	Est. Burkina Faso
2011	5	10	23	17	53.08	5.9	-5.3		4.3			133	NDC	cote d'ivoire
2011	5	15	05	26	40.09	4.5	-1.3		4.4			126	NDC	gulf of guinea, near ghana
2011	5	16	21	29	15.76	4.8	-5.2		4.1			115	NDC	gulf of guinea, near cote d'ivoire
2011	5	19	03	32	25.01	5.4	-5.4		4.0			95	NDC	cote d'ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2011	5	19	20	22	58.34	6.6	-4.9		4.2			39	NDC	Cote D'ivoire
2011	5	21	07	37	5.48	6.3	-4.6		4.1			146	NDC	Nzi-Comoe, Cote D'ivoire
2011	5	22	03	12	10.95	6.2	-5.3		4.3			145	NDC	Sud-Bandama, Cote D'ivoire
2011	5	25	15	31	15.76	8.0	-3.7		4.2			125	NDC	cote d'ivoire
2011	5	29	04	45	5.14	6.6	-4.7		4.1			100	NDC	Cote D'ivoire
2011	5	29	10	02	54.91	14.1	0.1		4.0			21	NDC	Burkina Faso
2011	5	30	22	45	15.35	6.6	-4.8		3.9			138	NDC	Cote D'ivoire
2011	6	03	03	68	26.43	6.6	-6.2		4.4			160	NDC	Haut-sassandra Cote D'ivoire
2011	6	03	06	35	55.56	5.6	-4.4		3.8			74	NDC	Cote D'ivoire
2011	6	11	22	35	26.63	6.3	-5.2		4.3			130	NDC	Bandama, Cote D'ivoire
2011	6	12	05	31	53.92	6.8	-5.0		4.2			130	NDC	Lacs, Cote D'ivoire
2011	6	13	02	40	53.85	13.5	0.7		3.8			61	NDC	Burkina Faso
2011	6	19	08	48	10.30	9.4	-2.7		4.4			128	NDC	Black Volta, Ghana
2011	6	19	10	06	24.80	5.4	-5.2		4.2			103	NDC	Sud-Bandama Cote D'ivoire
2011	6	23	13	09	10.53	7.5	-2.2		2.4			142	NDC	Odumase Rd Sunyani Ghana
2011	6	25	15	45	14.09	8.6	-5.4		2.2			102	NDC	Cote D'ivoire
2011	7	03	03	53	33.64	5.6	-2.8		4.4			7	NDC	Omanpe, near Ghana Cote d'Ivoire border
2011	7	06	17	34	31.07	5.3	-5.0		4.2			111	NDC	Lagunes, Cote d'Ivoire
2011	7	08	06	22	34.27	6.1	-4.9		4.1			121	NDC	Singrobo, Cote d'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2011	7	08	20	14	48.91	6.5	-3.5		4.1			20	NDC	Akouaba, Cote d'Ivoire
2011	7	09	23	20	59.36	3.0	-5.6		4.6			111	NDC	Coast of San-Pedro, Cote d'Ivoire
2011	7	09	23	36	18.67	-11.3	-10.3		4.1			138	NDC	off the coast of Liberia/ Cote d'Ivoire
2011	7	10	16	19	54.38	5.3	-4.5		4.4			77	NDC	Dabou, Cote Divoire
2011	7	10	19	12	34.73	10.1	-6.8		3.8			86	NDC	Zaniegue, Cote Divoire
2011	7	11	06	57	3.72	8.0	-5.1		4.0			103	NDC	Kadyoukaha, Cote Divore
2011	7	13	08	32	50.26	5.2	-5.0		4.3			109	NDC	Nzida, Cote Divoire
2011	7	15	11	41	49.27	6.6	-4.8		3.9			130	NDC	Dimbokro, Cote Divoire
2011	7	17	18	55	11.58	7.0	-5.7		3.8			37	NDC	Bouafle, Cote Divoire
2011	7	18	17	51	47.11	5.3	-5.2		4.2			106	NDC	Nzida, Cote Divoire
2011	7	22	00	21	26.57	6.0	-4.5		4.1			32	NDC	Rubino, Cote Divoire
2011	7	23	05	23	36.66	7.1	-4.3		2.2			138	NDC	Bocanda, Cote d'Ivoire
2011	7	25	04	43	5.35	-1.0	-7.4		4.1			105	NDC	off the coast of Liberia/ Cote d'Ivoire
2011	8	06	12	41	55.52	5.4	-1.8		3.9			6	NDC	Kwakuadjeikrom, W/R. Ghana.
2011	8	07	10	39	11.36	2.5	-5.7		4.3			108	NDC	Near coast of cote d'Ivoire
2011	8	08	06	56	31.41	7.7	-3.9		4.3			105	NDC	Koumasso, Cote d'lvoire
2011	8	09	06	21	32.28	6.7	-4.8		4.3			67	NDC	Assesbrakro, Cote d'Ivoire
2011	8	13	23	37	21.11	5.7	-4.2		4.1			64	NDC	Petit Yapo, Cote d'Ivoire
2011	8	14	08	01	0.20	6.5	-4.8		3.3			159	NDC	Guesseguie, cote d'lvoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2011	8	17	00	54	34.49	4.2	-5.0		4.4			94	NDC	Gulf of Guinea, Cote d'lvoire.
2011	8	17	12	30	9.77	4.4	-4.3		4.1			66	NDC	Coast of Cote D'lvoire.
2011	8	17	14	29	14.37	6.1	-6.2		4.0			156	NDC	Konayo, Cote d'Ivoire
2011	8	23	19	16	2.11	12.7	1.4		4.3			31	NDC	Kowari, Burkina Faso
2011	8	27	09	44	4.92	6.3	-6.3		4.4			165	NDC	Gugulie, Cote d'lvoire
2011	9	01	00	29	11.69	6.8	-6.2		4.2			177	NDC	Dignago, Cote d'lvoire
2011	9	04	12	27	4.63	-2.8	-7.8		4.0			67	NDC	off the Coast of Cote d'lvoire
2011	9	10	13	09	32.84	5.9	-6.1		3.8			151	NDC	Gohie, Cote d'lvoire
2011	9	11	06	48	14.70	2.6	-3.0		4.2			109	NDC	Near coast of cote d'lvoire
2011	9	12	18	02	48.37	5.6	-4.0		4.1			114	NDC	Nsakoi, Cote d'lvoire
2011	9	13	08	08	0.57	7.2	-3.6		4.6			154	NDC	Yacasse, Cote d'lvoire
2011	9	14	15	44	54.62	10.8	-4.1		3.9			80	NDC	Moribarasso, Burkina Faso
2011	9	15	20	29	24.94	11.7	2.7		4.5			116	NDC	Guene, Benin
2011	9	20	22	57	7.05	12.2	1.7		4.3			73	NDC	Byati, Burkina Faso
2011	9	21	18	12	47.42	5.3	-4.8		4.4			61	NDC	Tiagba, Cote d'lvoire
2011	9	23	13	21	7.14	-0.8	-5.5		4.3			103	NDC	off the coast of Cote d'lvoire
2011	9	23	21	19	58.57	6.1	-6.1		4.3			146	NDC	Kripayo, Cote d'lvoire
2011	9	25	01	29	31.04	6.4	-3.5		4.3			171	NDC	Blekoum, Cote d'lvoire
2011	9	26	05	02	6.07	6.1	-5.1		4.0			92	NDC	Goudi, Cote d'lvoire,

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2011	9	27	16	15	24.33	5.6	-4.0		4.1			55	NDC	Nasakoi, Cote d'Ivoire
2011	9	27	19	00	52.98	4.1	-5.6		4.4			74	NDC	Near coast of Cote D’Ivoire
2011	9	29	09	39	3.45	3.9	-3.3		3.7			88	NDC	Near coast Cote d'voire.
2011	10	05	09	01	20.39	-0.4	-8.0		4.2			100	NDC	off the coast of Liberia/Cote D'lvoice
2011	10	07	08	57	10.78	6.5	-5.9		4.2			154	NDC	Bahompa, Cote d'lvoire
2011	10	10	03	03	24.91	7.2	-4.5		4.3			74	NDC	Kokoboukro, Cote d'lvoire
2011	10	11	21	51	48.76	6.2	-2.3		3.9			167	NDC	Sefwi Bekwai, WR. Ghana
2011	10	12	23	14	42.79	13.4	0.9		4.0			9	NDC	Satyouri, Burkina Faso
2011	10	12	23	50	35.45	12.7	-3.6		3.9			87	NDC	Kour, Burkina Faso
2011	10	13	03	52	6.63	8.8	-7.1		4.6			41	NDC	Sebedian, Cote d'lvoire
2011	11	05	17	27	13.87	11.7	1.8		4.0			110	NDC	Nampondi, Burkina Faso
2011	11	06	09	01	51.25	6.0	-6.1		4.5			153	NDC	Digbahio, Cote d'lvoire
2011	11	06	09	12	58.96	12.7	-4.1		4.2			95	NDC	Soumbara, Burkina Faso
2011	11	08	21	08	44.95	12.7	-3.8		4.1			113	NDC	Niankui, Burkina Faso
2011	11	14	06	13	15.63	6.7	-2.3		4.4			161	NDC	Asuako, Ashanti Region, Ghana
2011	11	25	04	43	15.63	11.8	1.4		4.1			95	NDC	Arli National Park, Burkina Faso
2011	11	25	09	31	14.44	6.6	-4.9		4.2			57	NDC	Assebrakro, Cote d'lvoire
2011	11	27	22	18	14.52	7.4	-5.1		4.5			2	NDC	Mbouedio, Cote d'lvoire
2011	11	28	01	29	59.91	6.5	-3.5		3.7			166	NDC	Tanekron, Cote d'lvoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2011	11	29	11	30	48.52	7.2	-5.4		4.4			22	NDC	Gtogro, Cote d'lvoire
2011	12	03	09	26	8.58	-5.4	-5.6		4.7			136	NDC	off the coast of Cote d'lvoire/Ghana
2011	12	04	08	42	6.94	7.9	-4.3		4.2			117	NDC	Satama - Sokoura, Cote d'lvoire
2011	12	10	01	50	52.86	6.0	-5.0		4.3			91	NDC	Sokogrobo, Cote d'lvoire
2011	12	11	16	40	26.94	7.2	-4.3		4.0			143	NDC	Kamoukouanou, Cote d'lvoire
2011	12	17	20	40	10.21	13.4	0.8		4.1			11	NDC	Satyouri, Burkina Faso
2011	12	26	09	51	58.54	4.4	-4.3		4.5			44	NDC	Coast of Abidjan-Cote d'Ivoire
2011	12	26	13	29	45.81	11.8	1.8		4.0			101	NDC	Tombaga, Burkina Faso.
2011	12	27	01	37	58.83	-6.3	-1.5		4.0			47	NDC	off the coast of cote d'lvoire / Ghana.
2011	12	27	09	26	18.89	7.8	-4.2		4.3			122	NDC	Atokonou, Cote d'lvoire
2011	12	31	00	25	19.45	9.1	1.5		4.2			124	NDC	near Tchanba, Togo
2012	1	03	19	28	11.75	1.8	-0.5		4.3			97	NDC	in the Sea, off Coast of Ghana
2012	1	06	00	20	22.52	0.7	-3.9		4.0				NDC	Off Coast of Ivory Coast
2012	1	08	00	08	54.48	4.4	-3.5		4.1			83	NDC	Near coast of Ivory Coast
2012	1	11	17	36	37.96	7.7	-6.1		4.0			48	NDC	Kongaso, Cote d'lvoire
2012	1	20	10	07	0.85	7.0	-4.9		3.6			176	NDC	Bocanda, Cote d'lvoire
2012	1	22	19	48	49.53	7.2	2.0		2.1			131	NDC	Bhicon, Benin
2012	1	23	00	21	22.92	8.0	-4.4		4.0			91	NDC	Messarandougou, Cote d'lvoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2012	1	23	23	27	46.44	7.2	-4.1		3.7			135	NDC	Daoukro, Cote d'lvoire
2012	2	05	01	17	53.46	4.0	-2.5		4.0			149	NDC	Gulf of Gunea, Ghana
2012	2	06	00	20	38.89	11.8	2.1		4.0			113	NDC	Wide Burkina Faso National Park
2012	2	06	10	12	45.06	3.9	-4.2		4.5			108	NDC	Gulf of Gunea, near Abidjan
2012	2	07	16	41	27.01	6.7	-4.9		3.9			92	NDC	Dimbokro, Cote d'lvoire
2012	2	10	22	02	41.90	6.2	-5.4		3.8			137	NDC	Ovime, Cote d'lvoire
2012	2	16	04	16	13.84	5.9	-5.5		4.0			131	NDC	Gabiakok, Cote d'lvoire
2012	2	20	01	52	52.99	6.4	-5.0		4.2			33	NDC	Angbavia, Cote d'lvoire
2012	2	21	00	14	9.92	12.5	-1.7		4.1			123	NDC	Koudouwogen, Burkina Faso
2012	2	22	06	37	57.74	5.8	-4.0		4.6			25	NDC	Agbouille, Cote d'lvoire
2012	2	24	12	40	28.69	6.8	-5.0		4.1			150	NDC	Park National d' Abokonamekro
2012	3	10	01	32	43.70	3.0	-4.6		4.2			123	NDC	Near coast of Abidjan
2012	3	10	02	36	37.92	3.5	-0.7		4.2			146	NDC	Near Coast of Accra, Ghana
2012	3	11	03	57	16.50	7.5	-7.2		1.6			91	NDC	Man, Cote d'lvoire
2012	3	12	05	33	20.60	5.3	-4.6		4.1			95	NDC	Dabou, Cote d'Ivoire
2012	3	13	20	01	40.13	14.7	-1.3		3.8			113	NDC	Sahel Reserve, Burkina Faso
2012	3	14	18	19	51.21	5.5	-5.5		4.2			122	NDC	Borodou, Ivory Coast
2012	3	18	04	57	42.36	7.1	-4.8		4.1			103	NDC	Didievi, Ivory Coast.
2012	3	19	11	05	37.31	0.8	1.5		3.9			143	NDC	Off the coast of Ghana / Togo

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2012	3	20	06	05	7.29	9.9	-3.7		2.7			126	NDC	Kampti, Burkina Faso
2012	3	20	21	30	46.50	6.7	-4.9		3.9			58	NDC	Dimbokro, Cote d'lvoire
2012	3	21	22	36	32.06	-14.4	-4.2		4.4			156	NDC	off the coast of Ghana / Togo
2012	3	22	14	41	23.87	7.9	-4.1		4.0			119	NDC	Groumania, Cote d'lvoire
2012	3	23	03	59	9.52	7.1	-5.9		4.3			167	NDC	Bouafle, Cote d'lvoire
2012	3	27	23	32	42.80	12.3	1.4		4.1			106	NDC	Kantchari, Burkina Faso
2012	3	31	10	14	8.98	6.7	-4.9		4.0			12	NDC	Dimboko, Cote d'lvoire
2012	4	01	12	19	16.96	5.3	-4.5		4.0			95	NDC	Toupah, Cote d'lvoire
2012	4	07	06	19	45.99	12.4	1.3		4.0			120	NDC	Nalougou, Burkina Faso
2012	4	11	03	17	36.67	-3.3	-0.3		4.1			103	NDC	off the coast of Ghana
2012	4	11	04	05	35.72	-3.9	3.5		4.1			27	NDC	off the coast of Benin/Nigeria
2012	4	11	05	44	40.70	-16.8	-14.5		4.4			127	NDC	off the coast of Liberia/Cote d'Ivoire
2012	4	13	14	57	17.25	6.8	-4.2		4.3			88	NDC	Kotobi, Cote d'lvoire
2012	4	16	19	05	13.42	7.8	-5.6		3.9			69	NDC	Bandama, Cote d'lvoire
2012	4	16	21	59	47.67	0.4	-10.8		4.2			131	NDC	off the coast of Liberia/Cote d'Ivoire
2012	4	17	07	23	51.37	6.4	-6.2		6.2			165	NDC	Sauuia, Cote d'Ivoire
2012	4	17	08	02	21.03	5.3	-4.8		4.1			46	NDC	Bale de Cosrou, Cote d'lvoire
2012	4	19	00	14	58.90	4.2	-4.7		3.7			99	NDC	Gulf of Guinea, near Abidjan
2012	4	20	10	36	49.47	8.6	-5.6		4.1			60	NDC	Niakaramandougou, Cote d'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2012	4	24	04	11	41.65	13.5	0.9		4.0			18	NDC	Burkina Faso
2012	4	24	11	06	3.71	13.6	0.9		3.2			81	NDC	Burkina Faso
2012	4	24	19	15	13.57	7.1	-4.2		3.9			136	NDC	Bocanda, Cote d'Ivoire
2012	4	26	22	21	55.70	5.3	-4.6		4.0			87	NDC	laqune Ebrie, Cote d'lvoire
2012	4	27	06	19	43.29	7.0	-7.7		3.9			163	NDC	Bangolo, Cote d'lvoire
2012	4	28	10	28	8.98	-9.1	-1.9		4.4			92	NDC	Coast of Cote D'Ivoire
2012	4	28	23	26	4.08	6.6	-4.9		4.0			46	NDC	Toumodi, Cote d'Ivoire
2012	5	01	07	00	37.61	13.8	0.4		3.7			51	NDC	Dori,Burkina -Faso
2012	5	03	09	22	51.93	6.5	-4.8		4.2			157	NDC	Dimbokro,Cote D'ivoire
2012	5	07	12	24	43.55	5.9	-6.6		4.4			167	NDC	Badayo I,Cote De Voire
2012	5	08	13	28	30.59	5.4	-3.0		3.9			11	NDC	Affienou,Cote De Voire
2012	5	08	18	28	59.54	5.9	-4.3		4.3			28	NDC	Offa,Cote D'lvoire
2012	5	09	14	49	50.37	-1.1	-13.2		6.2			133	NDC	Off Coast Of Liberia/Cote D'lvoire
2012	5	11	16	36	58.82	6.7	-4.9		4.3			58	NDC	Toumodi,Cote D'lvoire
2012	5	14	03	38	21.48	6.6	-4.8		4.3			145	NDC	Dimbokro,Cote D'lvoire
2012	5	15	01	33	17.91	-4.9	-11.6		4.1			102	NDC	Off Coast Of Liberia/Cote D'lvoire
2012	5	17	04	59	5.89	5.9	-4.8		4.2			104	NDC	Tiassale,Cote D'lvoire
2012	5	18	11	55	6.21	-0.5	-6.7		4.2			127	NDC	Off Coast Of Liberia/Cote D'lvoire
2012	5	18	15	00	52.35	5.8	-6.1		4.2			144	NDC	Gohue,Cote D'lvoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2012	5	22	02	36	50.69	6.3	-3.3		4.0			69	NDC	Apopromponou,Cote D'voire
2012	5	25	02	59	58.70	5.3	-2.8		4.3			13	NDC	Kwesinimpa Impa, Cote D'ivoire
2012	5	25	17	43	36.45	7.0	-4.2		4.0			77	NDC	Daoukro, Cote D'ivoire
2012	5	26	11	35	21.52	6.6	-4.8		4.0			127	NDC	Daoukro, Cote D'ivoire
2012	5	31	17	23	32.63	7.2	-6.7		4.1			8	NDC	Vanona, Cote D'ivoire
2012	5	31	19	25	57.48	6.6	-4.9		3.9			13	NDC	Dimbokro, Cote D'ivoire
2012	6	18	16	08	22.64	6.4	-5.4		3.8			57	NDC	Oume,Cote d'lvoire
2012	6	20	00	59	14.49	7.0	2.2		2.5			131	NDC	Foret d Agrime, Benin
2012	6	21	07	26	38.40	7.3	-7.2		2.4			17	NDC	Man, Cote d'lvoire
2012	6	21	22	51	53.60	7.0	-6.0		4.3			18	NDC	Brozra, Cote d'lvoire
2012	7	04	11	38	43.89	8.6	-6.6		4.1			58	NDC	Kani, Cote d'lvoire
2012	7	11	14	39	22.68	6.8	-5.5		4.2			104	NDC	Konefia, Cote d'Ivoire
2012	7	15	14	20	21.92	7.1	-4.2		4.0			14	NDC	Daoukro, Cote d'lvoire
2012	7	18	16	08	22.64	6.4	-5.4		3.8			57	NDC	Oume, Cote d'lvoire
2012	7	28	06	00	13.51	6.1	-3.6		4.3			1	NDC	Adzope, Cote d'lvoire
2012	7	30	11	16	51.29	6.0	-3.4		3.9			27	NDC	Bettie, Cote d'lvoire
2012	8	4	12	59	22.40	13.0	-4.2		4.2			34	NDC	Djibasso, Burkina Faso
2012	8	4	18	21	2.47	5.4	-4.4		4.8			30	NDC	Orbaff, Cote d'lvoire
2012	8	5	19	11	45.08	11.9	2.4		4.0			83	NDC	Diapaga, Burkina Faso

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2012	8	6	13	6	31.78	-2.2	-6.5		4.0			42	NDC	Coast of Liberia/ Cote d'lvoire.
2012	8	6	15	11	11.34	11.2	-3.2		2.9				NDC	Kantchari, Burkina Faso
2012	8	7	11	36	56.91	12.5	1.2		4.3			38	NDC	Kantchari, Burkina Faso
2012	8	9	13	2	11.82	6.7	-4.8		4.4			3.7	NDC	Dimbokro, Cote d'lvoire
2012	8	11	22	2	38.60	6.7	-3.5		4.2			31	NDC	Abengouron, Cote d'lvoire.
2012	8	11	22	47	6.43	5.9	-4.5		2.9			28	NDC	Aboude Mendeke, Cote d'lvoire
2012	8	18	12	01	25.44	6.0	-3.6		4.2			158	NDC	Adzope, Cote d'Ivoire
2012	8	19	12	18	20.06	11.8	1.7		4.3			74	NDC	Near Tombaga, Burkina Faso
2012	8	21	06	45	56.74	6.2	-3.5		6.2			14	NDC	Near Abengova, Cote D'ivoire
2012	8	22	08	09	32.32	10.6	-1.9		2.0			135	NDC	Bechembeli, Upper West, Ghana
2012	9	06	12	06	9.16	5.7	-4.8		4.0			96	NDC	Ndouci, Cote d'lvoire
2012	9	17	20	17	21.53	7.7	-5.8		4.1			180	NDC	Beoumi, Cote d'lvoire
2012	9	21	13	09	8.79	5.2	-6.9		2.2			138	NDC	Tai National Park, Cote d'lvoire
2012	9	26	19	25	45.78	6.3	-0.5		4.2			136	NDC	Near Kwabeng, Ghana
2012	10	12	03	53	21.21	4.6	-4.6		4.1			104	NDC	Near the coast of Cote D'lvoire
2012	10	12	14	27	24.23	5.8	-5.9		4.0			24	NDC	Gueyo, Cote D'lvoire
2012	10	13	03	08	8.48	6.3	-2.2		2.7			163	NDC	Awaso, W/R., Ghana
2012	10	14	05	33	52.49	7.6	-6.5		4.3			30	NDC	Vavoua, Cote D'lvoire
2012	10	20	23	20	15	6.038	0.24	116	1.8				GGSA	Kasunya, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2012	10	26	23	29	38.13	8.0	-4.4		4.2			112	NDC	Satama Sokoro, Cote D'lvoire
2012	10	27	03	40	18.09	6.7	-4.8		3.5			103	NDC	Assebrakro, Cote D'lvoire
2012	10	27	23	19	43.08	5.6	-4.0		3.9			39	NDC	Atiekoi, Cote D'lvoire
2012	10	29	14	30	48.63	8.4	-4.3		4.4			106	NDC	Dabakala, Cote D'Ivoire
2012	10	29	17	51	45	6.302	-0.07	5.4	1.4				GGSA	Sikaman, Ghana
2012	10	30	22	00	12.88	0.9	-6.4		4.1			116	NDC	Coast of Cote D'Ivoire
2012	11	02	23	43	07.51	4.8	-2.8		3.8			15	NDC	Near the coast of Ghana
2012	11	04	00	30	50.40	12.2	1.8		4.1			95	NDC	Near Touaga, Burkina Faso
2012	11	04	05	11	59.40	12.0	1.2		4.0			119	NDC	Singou Reserve, Burkina Faso
2012	11	07	00	30	17.22	7.1	-5.2		4.0			75	NDC	Near Bomizabo, Cote d'Ivoire
2012	11	07	19	44	21.91	6.6	-6.3		4.4			26	NDC	Near Saouia, Cote d'Ivoire
2012	11	9	15	14	10	6.226	0.34	49	1.6				GGSA	Hevite,Ghana
2012	11	12	16	10	1	5.645	-1.39	4	1.8				GGSA	Ongwa,Ghana
2012	11	15	13	37	4	6.183	-0.08	9.1	3.75				GGSA	Odugbarisi,Ghana
2012	11	19	18	24	17	6.322	0.01	14	1.8				GGSA	Odonaw,Ghana
2012	11	20	12	20	26.47	5.4	-4.2		4.2			43	NDC	Near Attinguie, Cote d'Ivoire
2012	11	20	13	17	11	5.782	-0.52	4.7	1.6				GGSA	Okawso,Ghana
2012	11	21	12	21	23.43	6.6	-4.9		4.5			44	NDC	Near Totonou, Cote d'Ivoire
2012	11	21	12	21	46	6.115	-1.33	14	2.2				GGSA	Toankonse, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2012	11	25	17	48	53.42	6.8	-5.0		3.7			144	NDC	Near Amandie, Cote d'Ivoire
2012	11	26	01	39	15.61	11.5	0.5		4.0			129	NDC	Pama Reserve, Burkina Faso
2012	11	26	08	24	18.81	-2.8	-14.3		5.1			142	NDC	Off the Coast of Liberia
2012	11	27	19	46	52.02	6.2	-4.6		4.4			179	NDC	Rubino, Cote d'Ivoire
2012	11	29	01	17	19.96	5.3	-4.9		3.6			76	NDC	Assagny National Park, Cote d'Ivoire
2012	11	30	01	56	39.94	5.7	-5.8		4.5			99	NDC	Near Gague, Cote d'Ivoire
2012	11	30	9	46	15	6.135	0.38	21	1.6				GGSA	Gbanu, Ghana
2012	11	30	17	56	31	5.461	-0.7	10	2.2				GGSA	Abasa, Ghana
2012	12	05	00	08	37.35	6.2	-6.2		3.2			165	NDC	Near Guiberoua, Cote D'lvoire
2012	12	05	11	30	03.65	6.6	-5.5		4.4			25	NDC	Near Konefia, Cote D'lvoire
2012	12	06	06	58	51.91	6.8	-7.6		5.1			163	NDC	Near Duekoue, Cote D'lvoire
2012	12	6	8	31	49	6.04	0.02	27	1.7				GGSA	Akawli,Ghana
2012	12	07	15	34	28.29	14.3	-1.6		4.2			156	NDC	Near Djibo, Burkina Faso
2012	12	07	18	34	35.78	7.3	-0.4		4.5			77	NDC	Near Digya national park, Ghana
2012	12	09	01	35	56.37	3.8	-4.1		4.2			78	NDC	Near the coast of Cote D'lvoire
2012	12	09	22	36	23.77	6.7	-4.9		4.2			40	NDC	Near Dimbokro, Cote d'Ivoire
2012	12	12	09	32	48.20	0.8	0.1		4.4			147	NDC	Off the Coast of Ghana
2012	12	12	17	45	8	6.372	-0.51	182	2.4				GGSA	Asamang,Ghana
2012	12	13	6	39	40	6.097	-0.13	31	2				GGSA	Efiefi, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2012	12	13	7	9	50	5.952	-0.39	10	1.7				GGSA	Wawasi,Ghana
2012	12	13	11	43	02.34	3.7	-1.2		4.8			179	NDC	Near the Coast of Ghana
2012	12	13	11	48	20	4.647	0.13	3.3	2.3				GGSA	Near Wiaboman, Ghana
2012	12	14	08	35	14.63	5.9	-3.6		3.8			165	NDC	Near Abie, Cote d'Ivoire
2012	12	15	04	37	38.55	12.8	1.0		4.0			153	NDC	Near Bossongri, Burkina Faso
2012	12	15	05	00	47.56	-7.4	-14.3		4.6			150	NDC	Off the Coast of Liberia/Cote d'Ivoire
2012	12	16	03	07	46.73	6.4	-5.2		4.1			19	NDC	Near Groudji, Cote d'Ivoire
2012	12	16	03	36	27.45	13.7	-0.2		4.1			3	NDC	Near Bani, Burkina Faso
2012	12	16	14	31	45.04	5.4	-4.3		2.1			51	NDC	Near Le Nieky, Cote de d'Ivoire
2012	12	17	11	46	35.72	0.9	1.5		4.5			22	NDC	Off the Coast of Ghana
2012	12	19	7	46	12	7.203	-0.19	10	1.9				GGSA	Kodidi,Ghana
2012	12	19	16	04	59.29	6.3	-6.2		4.2			6	NDC	Near Guberoua, Cote D'lviore
2012	12	21	7	32	22	4.112	-0.4	15	2				GGSA	Gulf of Guinea, Near Coast of Ghana
2012	12	21	17	57	41	5.423	-0.61	6.2	2.3				GGSA	Ochreku,Ghana
2012	12	21	22	46	59	6.12	-0.28	413	1.4				GGSA	Asokori,Ghana
2012	12	23	13	22	23.88	6.8	-3.5		4.1			148	NDC	near Zinzenou, Cote D'lvoire
2012	12	24	12	23	38.81	13.0	-4.3		4.6			150	NDC	near Mandiakui, Burkina Faso
2012	12	26	13	01	36.89	-3.5	-4.9		4.3			107	NDC	Off the Coast of Cote d'Ivoire/Ghana
2012	12	26	13	47	31.02	4.6	-2.3		4.2			68	NDC	Near the Coast of Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2013	1	3	6	57	56	5.493	-0.47	14	1.2				GGSA	Abura, Ghana
2013	1	5	13	48	19	6.224	-0.09	7.9	2.5				GGSA	Bukunaw,Ghana
2013	1	7	10	1	38	5.004	0.54	14	2.1				GGSA	North Atlantic Ocean; Ghana
2013	1	7	12	55	19.96	7.559	-3.57		4.1			141	NDC	Koun, Cote D'lvoire
2013	1	8	8	38	32.85	11.48	3.45		4.2			65	NDC	Sende, Benin
2013	1	10	3	2	50.35	13.6	0.39		4.3			10	NDC	Fouga, Burkina Faso
2013	1	10	17	19	32	5.417	-0.3	54	1.7				GGSA	Chokome,Ghana
2013	1	13	7	8	35.46	6.062	-3.6		3.8			156	NDC	Adzope, Cote D'lvoire
2013	1	15	13	10	34	5.225	-0.34	10	1.8				GGSA	North Atlantic Ocean; Ghana
2013	1	15	13	48	19	6.173	-0.07	7.3	4.34				GGSA	Abotia,Ghana
2013	1	16	6	54	54	4.368	-0.67	23	2.2				GGSA	North Atlantic Ocean; Ghana
2013	1	16	21	56	27.07	5.41	-5.46		3.3			96	NDC	Borodou, Cote D'lvoire
2013	1	17	6	26	40.06	6.431	-5.25		4.1			147	NDC	Zangue, Cote D'lvoire
2013	1	17	18	42	34.03	6.449	-5.31		4.1			148	NDC	Zangue, Cote D'lvoire
2013	1	20	4	22	5.47	7.84	-6.25		4.2			58	NDC	Kongaso, Cote D'lvoire
2013	1	21	7	49	25	6.584	-1.28	25	1.1				GGSA	Nyamiyeadi,Ghana
2013	1	24	13	46	29.58	12.6	-2.23		3.5			123	NDC	Soum, Burkina Faso
2013	1	24	14	45	41	6.214	-0.11	19	1.8				GGSA	Bukuso,Ghana
2013	1	27	10	24	58.14	13.07	0.77		4.1			4	NDC	Liptongou Dept, Burkina Faso

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2013	1	28	13	27	59	8.323	-1.93	20	2.2				GGSA	Krampo,Ghana
2013	1	30	18	4	55	5.359	-0.46	11	1.9				GGSA	North Atlantic Ocean, Ghana
2013	1	31	3	53	39	6.154	0.19	5.1	1.6				GGSA	Nogopi,Ghana
2013	2	2	13	19	9	7.117	0.48	28	2.4				GGSA	Kledjo,Ghana
2013	2	2	23	15	17.04	-4.3	-7.05		4.5			122	NDC	Off the Coast of Cote d'Ivoire
2013	2	3	11	54	58.69	-0.2	1.11		4.1			57	NDC	Off the Coast of Ghana
2013	2	6	10	50	54.67	6.939	-4.1		4.2			28	NDC	Daoukro, Cote d'Ivoire
2013	2	7	1	24	2.26	6.424	-4.1		2.4			1	NDC	Akoupe, Cote d'Ivoire
2013	2	8	6	24	18.17	6.647	-4.83		3.9			132	NDC	Assebrakro, Cote d'Ivoire
2013	2	8	8	26	27.55	6.266	-5.5		4.4			151	NDC	Oume, Cote d'Ivoire
2013	2	8	11	31	9.38	-3.64	-0.58		4			124	NDC	Near Coast of Cape Coast; C/R, Ghana
2013	2	12	17	47	56	5.026	-0.22	0.7	2.3				GGSA	North Atlantic Ocean; Ghana
2013	2	14	11	30	1.11	6.752	-5.11		4.3			130	NDC	Near Yamoussoukro, Cote D'lvoire
2013	2	14	16	59	27.7	11.32	-3.7		4			129	NDC	Near Koumbia, Burkina Faso
2013	2	14	17	25	40	4.972	-0.17	14	2.1				GGSA	North Atlantic Ocean; Ghana
2013	2	17	6	4	8.63	3.98	1.38		3.7			180	NDC	Atlantc Ocean, Near the coast of Ghana/Togo
2013	2	19	16	40	12	7.736	-0.9	6	1.9				GGSA	Tintari,Ghana
2013	2	19	17	55	33	6.465	-0.09	85	2.1				GGSA	Kuma Kuma,Ghana
2013	2	20	10	3	8	7.986	-1.13	11	2				GGSA	Abeasi,Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2013	2	20	13	25	53	5.663	-0.51	0.8	1.9				GGSA	Ofrajato,Ghana
2013	2	22	16	35	53.81	5.924	-3.65		4			15	NDC	Near Adzope, Cote D'lvoire
2013	2	23	6	45	57	7.145	-0.01	44	1.8				GGSA	Abomasalafuo,Ghana
2013	2	23	8	20	21	4.932	-0.07	0.8	1.7				GGSA	South Atlantic Ocean
2013	2	23	11	28	13	6.082	0.23	6	1.8				GGSA	Koforidua, E/R, Ghana
2013	2	24	13	44	55	6.265	-0.11	5.3	2.4				GGSA	Bukunaw, Ghana
2013	2	26	17	5	26.61	6.724	-4.69		4.2			73	NDC	Near Dimbokro, Cote D'lvoire
2013	3	7	18	17	15	5.824	-0.13	9	2.6				GGSA	Oyibi, Ghana
2013	3	8	2	10	1.93	7.19	-5.95		4			21	NDC	Danangoro, Cote D'lvoire
2013	3	8	3	25	19	5.389	-0.52	3.4	1.7				GGSA	Akwasa, Ghana
2013	3	8	10	35	55.68	1.789	-7.19		4.1			172	NDC	Cote D'lvoire/Liberia Coast
2013	3	8	22	50	2.93	5.938	-4.33		4.5			133	NDC	Offa, Cote D'lvoire
2013	3	9	15	1	23	6.234	-0.08	5	1.9				GGSA	Okpesi, Ghana
2013	3	10	23	11	16	6.806	-0.26	10	2.2				GGSA	Fradaka,Ghana
2013	3	11	20	28	10.57	7.746	-5.8		2.3			64	NDC	Agbao, Cote D'lvoire
2013	3	12	6	40	46.74	13.75	-0.95		3.9			165	NDC	Nama, Burkina Faso
2013	3	12	9	40	6.15	6.374	-2.03		4.1			175	NDC	Manso-Nkanta, A/S, Ghana
2013	3	13	13	51	14	5.804	-1.13	1.3	1.5				GGSA	Assin North, C/R, Ghana
2013	3	14	9	37	19	5.115	-0.51	8.3	1.7				GGSA	North Atlantic Ocean,Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2013	3	17	10	7	44	5.335	-0.21	5	2.3				GGSA	North Atlantic Ocean,Ghana
2013	3	18	12	3	9	8.863	-1.69	9	1.9				GGSA	Central Gonja, Ghana
2013	3	18	14	39	58.23	6.648	-4.84		4.2			147	NDC	Dimbokro, Cote D'lvoire
2013	3	19	6	32	14	8.313	-1.29	26	1.9				GGSA	Saronoase,Ghana
2013	3	21	6	32	39	7.299	-0.66	3	2.1				GGSA	Sekyere East, A/R, Ghana
2013	3	23	17	40	52.99	5.629	-3.9		4.4			28	NDC	Nsakoi, Cote D'lvoire
2013	3	24	2	35	13.66	7.165	-6.15		3.8			35	NDC	Baboulifla, cote D'lvoire
2013	3	25	4	16	11.46	9.951	-6.13		3.8			67	NDC	M'bengue, Cote D'Ivoire
2013	3	27	7	12	35.78	6.801	-5.25		4.1			120	NDC	Yamoussoukro, Cote D'Ivoire
2013	3	28	8	50	57.55	9.074	-1.45		1.9			136	NDC	Busunu, N/R, Ghana
2013	3	28	12	55	40.93	12.34	0.54		4.1			33	NDC	Yamba Department, Burkina Faso
2013	3	29	6	20	27	6.587	-0.4	12	1.9				GGSA	Amate,Ghana
2013	3	29	7	42	47	6.469	-0.7	9.3	2				GGSA	Asuboni Station,Ghana
2013	3	29	14	4	21.75	7.572	-7.99		3.7			168	NDC	Kouan-Houle, Cote D'Ivoire
2013	3	29	15	18	33.74	3.883	-4.07		3.7			101	NDC	coast of Abidjan, Cote D'Ivoire
2013	3	30	10	20	4	9.138	-0.5	6.9	1.9				GGSA	Kwisini,Ghana
2013	3	30	11	43	3	5.862	-0.47	5	1.4				GGSA	Achiasi, Ghana
2013	3	30	16	10	19.04	6.29	-3.53		3.8			38	NDC	Mbasso, Cotr D'Ivoire
2013	3	30	17	43	28	4.707	-0.39	12	2.2				GGSA	North Atlantic Ocean; Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2013	3	30	18	45	58.98	-12.7	-15.1		3.9			106	NDC	Off the coast of Liberia/Cote D'Ivoire
2013	3	31	18	1	16	6.552	0.44	15	1.7				GGSA	Vodje,Ghana
2013	4	1	10	49	54.29	5.288	-5.09		4.4			120	NDC	Nzida, Cote D'Ivoire
2013	4	1	22	26	2.82	12.2	2.73		4			103	NDC	Monsey, Benin
2013	4	2	5	46	54.67	4.77	-4.93		4.2			91	NDC	Near the coast of Cote D'Ivoire
2013	4	2	13	32	2	5.742	-0.2	82	1.9				GGSA	Pantan ,Ghana
2013	4	2	23	10	25.36	12.39	1.08		3.9			132	NDC	Kantchari Dept., Burkina Faso
2013	4	3	7	9	59	7.125	-1.21	191	2				GGSA	Jadiako,Ghana
2013	4	5	20	14	56.17	33.99	25.8		4.1			23	NDC	Off the coast of Egypt
2013	4	6	5	2	51.22	-1.55	-0.17		4.7			137	NDC	Off the east coast of Ghana
2013	4	6	11	32	51	6.125	0.65	8.7	2.1				GGSA	Bakpa, Ghana
2013	4	7	15	54	43	5.79	-0.77	8.4	2.3				GGSA	Asuaso, Ghana
2013	4	8	7	51	52.64	6.493	-5.1		4.3			55	NDC	Toumodi, Cote D'Ivoire
2013	4	8	18	16	22	7.258	0.23	216	2.3				GGSA	Odumasi,Ghana
2013	4	17	13	14	43.8	5.846	-3.67		4.2			11	NDC	Palmraie, Côte d'Ivoire
2013	4	17	13	34	51.3	5.317	-4.61		3.9			111	NDC	Palmraie, Côte d'Ivoire
2013	4	17	15	37	58.23	2.501	-1.7		3.7			109	NDC	Palmraie, Côte d'Ivoire
2013	4	17	17	30	43	5.336	-0.53	7.6	2.5				GGSA	North Atlantic Ocean; Ghana
2013	4	18	15	0	57	5.191	-1.85	34	2.2				GGSA	Subriso, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2013	4	18	18	15	53	5.541	-0.53	12	2.2				GGSA	Chinankama,Ghana
2013	4	24	21	31	5.98	6.973	-5.6		2.1			84	NDC	Bouafle, Côte d'Ivoire
2013	4	24	21	33	14.62	3.782	-0.33		4.2			173	NDC	Near Accra coast, Ghana
2013	4	27	22	1	13.74	6.632	-4.62		3.8			104	NDC	Dimbokro, Cote d'voire
2013	4	28	22	21	6.41	7.601	-3.82		4.1			121	NDC	Bondoukou, Côte d'Ivoire
2013	4	30	13	1	35.23	7.731	-2.91		3.7			133	NDC	Bondoukou, Côte d'Ivoire
2013	4	30	20	9	17.28	5.849	-5.14		4			90	NDC	Ble, Côte d'Ivoire
2013	5	1	4	35	43.11	30.92	-12.8		3.7			135	NDC	off the coast of Morocco
2013	5	2	8	35	1.39	11.37	1.22		3.6			121	NDC	Arli National Park, Burkina Faso
2013	5	2	17	48	30	4.527	0.63	108	2				GGSA	North Atlantic Ocean; Ghana
2013	5	4	6	49	50.18	5.969	-3.72		4.3			23	NDC	NIA, Adzope, Cote D'Ivoire
2013	5	4	22	46	6.22	5.377	-5.44		4.3			140	NDC	Guitri, Cote D'Ivoire
2013	5	5	8	44	0.65	12.47	0.5		4			171	NDC	Gayeri, Burkina Faso
2013	5	12	1	49	49.4	11.82	3.32		4.3			50	NDC	Tomboutou, Benin
2013	5	14	1	14	6.33	8.736	-6.12		3.7			71	NDC	Sityokaha, Côte d'Ivoire
2013	5	14	15	47	49.01	5.077	-6.06		4.2			138	NDC	Sassandra, Côte d'Ivoire
2013	5	15	14	9	4.24	8.113	-4.85		4.3			83	NDC	Katiola, Côte d'Ivoire
2013	5	16	16	31	42.29	4.218	-4.02		4			103	NDC	Off the coast of Côte d'Ivoire
2013	5	16	19	13	35	5.561	-0.58	8.6	1.7				GGSA	Akwechi,Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2013	5	18	18	16	46	5.218	-0.44	29	2.6				GGSA	North Atlantic Ocean; Ghana
2013	5	18	18	17	4	6.096	0.01	6.3	2				GGSA	Tuklue, Ghana
2013	5	18	20	16	56.46	13.1	-1.97		2			146	NDC	Kirsi Dept, Burkina Faso
2013	5	21	2	14	47.05	9.041	-4.86		3.6			86	NDC	Noumouso, Cote D'Ivoire
2013	5	23	0	0	54.93	6.597	-4.82		3.8			148	NDC	Bofrebo, Cote D'Ivoire
2013	5	23	13	17	44	6.122	0.32	16	2.4				GGSA	Nutekpo,Ghana
2013	5	23	17	38	18	5.269	-0.5	32	1.5				GGSA	North Atlantic Ocean; Ghana
2013	5	24	6	8	30	5.995	0.39	4.7	3				GGSA	Ngunukope, Ghana
2013	5	24	6	39	44	7.785	-0.48	407	1.9				GGSA	Kofe Djan ,Ghana
2013	5	24	15	13	35	6.863	-0.4	206	3				GGSA	Abon-Fo, Ghana
2013	5	25	3	15	7	5.518	-0.29	11	2.2				GGSA	Shiayena,Ghana
2013	5	27	14	42	49.48	11.34	1.03		4			125	NDC	Arli National Park, Bur. Faso
2013	5	29	18	7	43	6.024	-0.5	10	1.4				GGSA	Near Suhum, Ghana
2013	5	30	7	20	33.75	6.624	-5.44		3.9			170	NDC	Konefla, Cote D'Ivoire
2013	5	30	12	5	43.31	6.782	-4.8		3.9			27	NDC	Dimbokro, Cote D'Ivoire
2013	5	31	17	56	31	5.493	-0.63	7.2	2.6				GGSA	Echifikwa,Ghana
2013	6	3	8	21	39	5.853	0.34	12	1.9				GGSA	North Atlantic Ocean; Ghana
2013	6	3	12	17	47	6.127	-1.21	10	2.1				GGSA	Adansi Nsese,Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2013	6	5	5	7	16	6.929	-0.2	5.3	1.9				GGSA	Uninhabitated side, Ghana
2013	6	6	13	47	47	5.748	-0.44	18	2.4				GGSA	Asuaba,Ghana
2013	6	18	7	33	2	6.281	-1.36	19	1.6				GGSA	Fwereso, Ghana
2013	6	20	2	6	47.1	6.849	-4.19		4.2			129	NDC	Agbosso, Cote D'Ivoire
2013	6	24	8	20	58	6.579	-0.12	226	1.9				GGSA	Chwerebuana, Ghana
2013	6	25	7	11	18.08	32.84	7.46		4.4			159	NDC	Nakhla
2013	6	25	13	14	19.46	7.198	-4.91		4			100	NDC	Didievi, Cote D'Ivoire
2013	6	26	3	29	59.89	32.81	25.8		4			16	NDC	Near the coast of Egypt
2013	6	26	21	7	13.06	34.12	25.1		3.9			139	NDC	Off the coast of Libya/ Egypt
2013	6	27	22	24	0.2	26.6	6.51		3.5			111	NDC	Ain Salah
2013	6	27	23	2	29.97	33.77	29.7		4			24	NDC	Off the coast of Egypt
2013	6	28	4	47	0.14	34	-10.5		3.6			74	NDC	Near the coast of Morocco
2013	6	28	12	22	12	5.809	-0.71	6.2	2				GGSA	Swedru,Ghana
2013	6	28	13	19	38	8.559	-1.42	12	2				GGSA	Nkoranza, Ghana
2013	6	29	6	42	53.73	5.311	-3.48		3.9			169	NDC	Asse, Cote D'Ivoire
2013	6	29	23	53	9.38	23	24.7		3.9			91	NDC	Al Jawf
2013	6	30	13	23	21.77	6.056	-3.99		3.9			164	NDC	Akoudzin, Cote D'Ivoire
2013	7	2	11	27	48	7.531	0.16	12	2				GGSA	Owankwae,Ghana
2013	7	4	13	40	19	6.116	0.34	22	2.5				GGSA	Nutekpo, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2013	7	5	1	1	1	12.43	0.45		2.4			150	NDC	Doundougou, Burkina Faso
2013	7	6	14	31	56.11	12.64	0.62		4.1			157	NDC	Gayeri, Burkina Faso
2013	7	7	5	39	8	5.395	-0.43	20	1.7				GGSA	Brofoyedru, Ghana
2013	7	8	17	15	32.88	6.761	-4.71		4.3			64	NDC	Dimbokro, Adiakoukonankro
2013	7	11	16	0	41.99	6.21	-4.37		4.2			62	NDC	Rubino, Cote D'Ivoire
2013	7	13	8	47	27.02	7.068	-4.41		4.1			1	NDC	Sale-Balekro, Cote D'Ivoire
2013	7	14	13	57	5.65	5.046	-4.09		4			63	NDC	Near the coas of Cote D'Ivoire
2013	7	16	18	41	6	5.421	-0.58	7.5	2.2				GGSA	Ojinjinadzi,Ghana
2013	7	22	22	53	44.01	5.086	-6.8		4.1			113	NDC	Dogbo, Cote D'Ivoire
2013	7	23	21	41	31.29	6.602	-4.86		4			180	NDC	Loukouyakro, Cote D'Ivoire
2013	7	25	14	47	4	5.421	-0.6	5.3	2.4				GGSA	Ochreku,Ghana
2013	7	26	14	46	38.7	6.489	-4.94		4.1			23	NDC	Assemboue, Cote D'Ivoire
2013	7	29	15	0	7	5.462	-0.32	31	2.7				GGSA	Chokome,Ghana
2013	8	1	20	21	46.74	-16.5	-1.67		4.2			115	NDC	Off the coast of Ghana/Cote d' Ivoire
2013	8	2	15	22	6.78	5.396	-4.86		4.1			94	NDC	Bandama, Cote d'Ivoire
2013	8	3	4	54	2	6.031	-0.37	7.5	1.8				GGSA	Akorabu Kukua,Ghana
2013	8	3	12	42	16.23	3.222	-0.85		2.8			156	NDC	Coast of Cape Coast, Ghana
2013	8	5	21	11	9	5.51	-0.52	11	2.3				GGSA	Obutu,Ghana
2013	8	6	8	40	38.46	11.46	2.65		4.4			83	NDC	Gomparou, Benin

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2013	8	8	0	49	22.28	9.014	-3.88		4			107	NDC	Comoé National Park, Cote d'ivoire
2013	8	9	11	42	51	5.337	0.78	23	2				GGSA	North Atlantic Ocean; Ghana
2013	8	13	6	12	9.41	13.21	-1.56		4.4			118	NDC	Rouko Dept, Burkina Faso
2013	8	14	21	39	31.27	12.21	1.68		4.3			105	NDC	Diapaga, Burkina Faso
2013	8	18	7	46	24.88	5.588	-3.99		4.2			57	NDC	Atiekoi, Côte d'Ivoire
2013	8	18	15	43	59	5.627	-0.47	18	2.2				GGSA	Owulabu, Ghana
2013	8	20	21	40	4	5.366	0.17	4	3.1				GGSA	North Atlantic Ocean; Ghana
2013	8	25	1	57	14.28	4.209	-6.77		3.9			134	NDC	Near the coast of Cote d'Ivoire
2013	8	25	14	22	26.15	7.477	-6.4		4.3			47	NDC	Vavoua, Côte d'Ivoire
2013	8	25	23	21	38.38	7.145	-4.45		4.3			155	NDC	Bocanda, Côte d'Ivoire
2013	8	30	14	12	45.82	5.278	-4.72		4.2			108	NDC	Tiagba, Côte d'Ivoire
2013	8	31	12	32	9	5.415	-0.19	34	2.6				GGSA	North Atlantic Ocean; Ghana
2013	8	31	19	16	13.86	6.078	-3.63		2.5			5	NDC	Adzope, Côte d'Ivoire
2013	9	3	8	35	35.7	6.574	-4.92		4.3			28	NDC	Toumodi, Côte d'Ivoire
2013	9	4	6	6	54.18	5.373	-5.59		3.9			122	NDC	Guitri, Côte d'Ivoire
2013	9	4	9	22	40	5.617	-0.35	20	1.8				GGSA	Joma,Ghana
2013	9	6	10	38	50	6.949	-0.27	11	2				GGSA	Fiasi,Ghana
2013	9	6	10	48	35	5.518	-1.25	6.1	2.1				GGSA	Ajueso,Ghana
2013	9	6	21	26	1	4.648	0.96	20	2.3				GGSA	North Atlantic Ocean,Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2013	9	11	11	59	26.88	6.872	-5.16		4.5			117		Yamoussoukro, Côte d'Ivoire
2013	9	18	12	35	50	7.683	-0.67	91	2.4				GGSA	Lesi,Ghana
2013	9	23	13	33	56.87	6.694	-4.73		4.1			80	NDC	Dimbokro, Côte d'Ivoire
2013	9	24	1	18	59.37	5.369	-4.85		4			98	NDC	Dimbokro, Côte d'Ivoire
2013	9	25	6	22	34.44	6.606	-4.82		4.2			148	NDC	Dimbokro, Côte d'Ivoire
2013	9	25	14	36	47.35	6.558	-5.96		4.2			7	NDC	Sinfra, Côte d'Ivoire
2013	9	25	16	54	19	6.047	-0.05	0.1					GGSA	Akode,Ghana
2013	9	27	15	11	12.72	-2.98	-10.8		3.4			132	NDC	Off the coast of Côte d'Ivoire
2013	9	30	3	36	37.9	6.045	-5.53		4			139	NDC	Gabiakoko, Côte d'Ivoire
2013	9	30	21	33	7	4.312	0.89	55	2.1				GGSA	North Atlantic Ocean,Ghana
2013	10	5	6	31	20.77	-7.39	-6.39		4.5			161	NDC	Near Coast Of Cote D'ivoire
2013	10	7	7	11	7	5.904	-1.18	6.4	1.8				GGSA	Dupenasi,Ghana
2013	10	9	6	51	0	6.806	-1.73	20	1.7				GGSA	Adankwamu, Ghana
2013	10	13	13	2	14.93	4.942	-5.57		4.5			121	NDC	Near Sassandra Côte D'ivoire
2013	10	15	20	30	34.19	12.54	0.43		4.4			150	NDC	Near Gayeri,Burkina Faso
2013	10	16	2	44	59.41	5.289	-5.14		4.3			128	NDC	Near Nzida, Côte D'ivoire
2013	10	19	23	16	7.4	12.68	-0.24		4.3			131	NDC	Near Boulsa, Burkina Faso
2013	10	20	18	55	53.19	7.43	-8.03		1.9			148	NDC	Kouan-Houle, Côte D'ivoire
2013	10	20	22	47	49.72	7.943	-2.65		1.3			140	NDC	Near Kabile,Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2013	10	29	20	9	11.04	5.647	-3.87		3.9			29	NDC	Near Yacasse,Ivory Coast
2013	11	1	9	36	56.72	6.553	-4.59		4.1			111	NDC	Near Dimbokro,Ivory Coast
2013	11	10	5	26	47.75	6.674	-4.84		4.4			73	NDC	Near Dimbokro,Ivory Coast
2013	11	16	3	45	34.35	-3.21	-3.02		4.9			125	NDC	Sekondi-Takoradi,Ghana
2013	12	1	0	32	30.78	13.61	0.34		4.1			3	NDC	Liptougou Dept, Burkina Faso
2013	12	1	11	9	4.19	6.549	-3.04		3.2			169	NDC	Adwuofua, Western Region
2013	12	1	17	29	31.81	5.623	-4.26		4.1			66	NDC	Atteou, Cote D'ivoire
2013	12	4	11	28	34.54	7.331	-3.65		4.2			133	NDC	Daoukro, Cote D'ivoire
2013	12	8	9	43	53.49	7.059	-5.05		4.4			119	NDC	D'abokouamekro, Cote D'ivoire
2013	12	12	7	48	49.99	6.548	-4.08		3.4			167	NDC	Bonguoanou, Cote D'ivoire
2013	12	17	4	7	8.65	13.33	0.91		4			25	NDC	Liptougou Dept, Burkina Faso
2013	12	17	14	20	8	5.358	-0.3	422	2.1				GGSA	North Atlantic Ocean; Ghana
2013	12	20	0	43	9.15	5.582	-6.44		3.9			158	NDC	Soubré, Côte D'ivoire
2013	12	25	17	27	47.01	6.378	-5.44		4.3			155	NDC	Oume, Cote D'ivoire
2013	12	27	9	12	35.05	14.38	0.21		3.8			51	NDC	Falagountuo, Burkina Fasso
2013	12	29	13	14	20.2	9.492	-5.76		4.2			66	NDC	Korhogo, Cote D'ivoire
2013	12	31	13	36	22.49	1.926	-2.8		2.5			83	NDC	Coast Of Cote D’ivoire/Ghana
2013	12	31	18	17	7	5.52	0.55		2.8				GGSA	Gulf of Guinea, Near Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2013	12	31	22	34	45.59	10.6	0.34		4.1			134	NDC	Barkoisi, Togo
2014	1	1	0	26	10.24	6.715	-4.77		3.7			63	NDC	Dimbokro, Cote D'ivoire
2014	1	2	4	9	56.37	6.489	-4.53		4.4			116	NDC	Dimbokro, Cote D'ivoire
2014	1	2	9	22	45	6.686	-0.93	10	1.6				GGSA	Gomoa Fetteh, C/R, Ghana
2014	1	3	1	44	20.91	8.03	0.36		1.8			139	NDC	Kparepare, Ghana
2014	1	3	8	14	6.07	6.515	-4.8		3.9			161	NDC	Dimbokro, Cote D'ivoire
2014	1	4	5	43	38.19	7.992	-4.53		4.1			103	NDC	Santama-Sokoro, Cote D'ivoire
2014	1	9	18	4	7	5.254	-0.31	2.2	2.1				GGSA	North Atlantic Ocean; Ghana
2014	1	10	1	7	4	6.259	0.03	8.9	1.5				GGSA	Tawtibo, Ghana
2014	1	14	2	8	54.28	6.235	-4.76		3.9			27	NDC	Bandama, Cote D'ivoire
2014	1	18	6	24	4	5.428	-0.45	8.3	2.3				GGSA	Gomoa Fetteh, C/R, 0233, Ghana
2014	1	19	16	47	52.28	7.731	-4.06		4			129	NDC	M'bahiakro, Cote D'ivoire
2014	1	21	5	39	31.13	13.02	0.29		4.4			150	NDC	Gnagna, Burkina Faso
2014	1	21	18	55	0	5.514	0.29	0	2.5				GGSA	North Atlantic Ocean,Ghana
2014	1	23	10	24	3	5.77	-0.41	13	2.2				GGSA	Ga West Municipal
2014	1	26	15	50	4.24	6.656	-4.86		3.9			19	NDC	Dimbokro, Côte D'ivoire
2014	1	26	20	29	10.8	10.89	-2.9		3.8			129	NDC	Ouessa, Burkina Faso
2014	2	1	22	53	26.21	5.389	-5.34		4.2			100	NDC	Guitri, Cote D'ivoire
2014	2	2	1	27	31.32	5.265	-5.08		3.1			100	NDC	Nzida, Cote D'ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2014	2	4	6	48	11	6.753	-0.19	32	1.6				GGSA	Volta Lake,Ghana
2014	2	5	9	34	57	5.787	-0.46	0	2.5				GGSA	Adeiso,Ghana
2014	2	5	16	36	7	7.063	0.16	80	2.2				GGSA	Volta Lake,Ghana
2014	2	6	7	50	20.53	7.229	-6.17		3.9			5	NDC	Marahoue National Park, Cote D'ivoire
2014	2	7	10	36	7	5.93	-0.46	24	1.4				GGSA	Asuboe,Ghana
2014	2	7	11	8	51	6.378	0.31	12	1.6				GGSA	Apeguso,Ghana
2014	2	7	11	16	37	9.571	-1.15	0	1.9				GGSA	Kumbungu,Ghana
2014	2	7	17	44	31.78	5.049	-3.82		4.1			82	NDC	Near Coast Of Grand-Bassam, Cote D'ivoire
2014	2	8	16	18	47	6.151	-0.27	1.7	2.1				GGSA	Nkurakan,Ghana
2014	2	8	20	2	19.76	2.347	-0.36		4.5			76	NDC	Secondi-Takoradi, Ghana
2014	2	11	4	11	36.45	6.458	-4.86		3.9			158	NDC	Toumodi, Cote D'ivoire
2014	2	11	16	21	19.05	6.299	-4.7		3.8			160	NDC	Toumodi, Cote D'ivoire
2014	2	12	18	49	32	6.59	0.47	157	2.3				GGSA	Klefe,Ghana
2014	2	15	7	53	17.81	7.191	-0.24		2.3			141	NDC	Digya National Park, Ghana
2014	2	17	20	58	6.24	8.637	-2.9		3.1			137	NDC	Koutouba, Cote D'ivoire
2014	2	19	15	20	30.51	6.638	-4.86		3.9			10	NDC	Dimbokro, Cote D'ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2014	2	21	16	46	22.64	5.924	-4.83		4.4			61	NDC	Bandama, Cote D'ivoire
2014	2	23	13	17	50.89	7.044	-4.33		3.7			73	NDC	Bocanda, Cote D'ivoire
2014	2	24	1	17	27.63	6.655	-4.88		3.5			53	NDC	Dimbokro, Cote D'ivoire
2014	2	25	23	39	58.26	6.731	-3.48		4.1			154	NDC	Abengourou, Cote D'ivoire
2014	2	27	17	28	51	5.504	-0.5	24	2.7				GGSA	Budumburam,Ghana
2014	2	28	19	5	44.92	14.6	-0.4		4			41	NDC	Sahel Reserve, Burkina Faso
2014	3	1	3	59	41.08	6.636	-3.49		4.1			158	NDC	Abengourou, Cote D'ivoire
2014	3	2	10	18	42.34	8.581	0.64		1.6			135	NDC	Satouboua, Togo
2014	3	7	15	58	18.37	6.623	-5.82		4			167	NDC	Sinfra, Cote D'ivoire
2014	3	7	21	42	49	6.465	-0.28	35	1.8				GGSA	Adawso,Ghana
2014	3	9	23	8	12.04	6.724	-4.87		4			162	NDC	Dimbokro, Cote D'ivoire
2014	3	10	9	40	7.73	8.323	-4.48		4			97	NDC	Dabakala, Cote D'ivoire
2014	3	10	18	2	34.57	7.105	-4.7		4.2			15	NDC	Bocanda, Cote D'ivoire
2014	3	11	18	38	3	6.534	-0.55	132	2.7				GGSA	Kankan,Ghana
2014	3	12	10	38	28	4.787	-0.6	18	1.9				GGSA	North Atlantic Ocean,Ghana
2014	3	12	12	28	24	6.461	-0.37	5.9	2.5				GGSA	Begoro,Ghana
2014	3	13	13	51	26.93	9.265	-3.98		3.8			115	NDC	Comoe National Park, Cote D'ivoire
2014	3	15	5	17	40.46	0.196	-7.55		4			119	NDC	Coast Of Liberia/Cote D'ivoire
2014	3	15	17	36	34.18	6.474	-4.89		4			9	NDC	Toumodi, Cote D'ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2014	3	16	12	2	39	5.869	-1.18	6.6	2.2				GGSA	Swedru,Ghana
2014	3	17	7	43	28.83	7.124	-4.27		4.3			134	NDC	Bocanda, Cote D'ivoire
2014	3	21	15	2	46.23	8.051	-2.63		3.7			142	NDC	Jaman North, Cote D'ivoire
2014	3	21	15	56	37.18	7.436	-6.02		4.3			69	NDC	Zuenoula, Cote D'ivoire
2014	3	21	20	2	9	8.388	-1.58	18	1.9				GGSA	Kintampo,Ghana
2014	3	22	0	25	2.78	11.7	1.59		4.1			90	NDC	Tapoa, Burkina Faso
2014	3	23	10	18	24.44	4.3	-1.05		3.7			1	NDC	Near The Coast Of Takoradi, Ghana
2014	3	24	23	56	29.06	6.638	-4.82		4.1			128	NDC	Dimbokro, Cote D'ivoire
2014	3	25	20	39	24.6	5.433	-4.12		4.3			71	NDC	Gounioube, Cote D'ivoire
2014	3	26	11	39	4.03	12.98	-2.03		3.9			166	NDC	Passore, Burkina Faso
2014	3	26	13	2	0	5.538	-0.94	7.7	1.9				GGSA	Bobikuma,Ghana
2014	3	27	16	22	24	6.073	-0.27	0.7	1.9				GGSA	Koforidua,Ghana
2014	4	2	16	54	20.84	5.626	-5.38		4.5			123	NDC	Guitri, Cote D'ivoire
2014	4	4	19	48	44.68	5.358	-5.28		4.5			121	NDC	Guitri, Cote D'ivoire
2014	4	12	20	33	4.48	0.705	-6.19		4.9			114	NDC	San-Pedro, Cote D'Ivoire
2014	4	13	12	3	13.11	6.679	-4.88		4.2			114	NDC	Dimbokro, Cote D'ivoire
2014	4	15	5	11	24.17	5.892	-2.14		4.1			30	NDC	Ankobra River, Ashanti Region,
2014	4	19	18	15	50.76	6.377	-5.64		3.9			175	NDC	Guepaouo, Cote D'ivoire
2014	4	20	10	1	57.25	5.326	-5.15		4.3			92	NDC	Nzida, Cote D'ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2014	4	20	22	12	10.23	5.312	-4.65		3.9			75	NDC	Nzida, Cote D'ivoire
2014	4	22	19	54	9.67	6.593	-2.02		4.5			148	NDC	Nyinahin, Kumasi, Ghana
2014	4	26	1	42	39.56	12.18	2.68		4			18	NDC	W National Park, Benin
2014	5	1	16	23	30.02	5.782	-6.2		4.4			146	NDC	Gueyo,Cote D'lvoire
2014	5	6	11	25	7.23	7.244	-3.32		4.2			155	NDC	Tankesse,Cote D'lvoire
2014	5	6	22	9	11.55	5.863	-6.7		3.3			163	NDC	Yabayo,Cote D'lvoire
2014	5	8	6	22	39.05	7.104	1.38		2.4			131	NDC	Foret De Tchicla Monata, Togo
2014	5	10	3	43	36.1	7.264	-3.05		4			151	NDC	Tanda, Cote D'ivoire
2014	5	19	13	15	33.93	5.343	-4.27		4.3			58	NDC	Songon-Agban, Cote D'ivoire
2014	5	19	22	57	45.07	6.102	-4.6		3.8			12	NDC	Tiassale, Cote D'ivoire
2014	5	27	6	22	7.33	6.467	-4.71		3.8			142	NDC	Bongouanou, Cote D'ivoire
2014	5	28	0	14	41.76	6.381	-4.94		3.9			123	NDC	Toumodi, Cote D'ivoire
2014	6	2	11	48	41.47	6.776	-8.19		4.2			30	NDC	Zouan - Hounien, Cote D'ivoire
2014	6	5	6	5	4.44	7.206	-5.01		4.1			88	NDC	D'abokouamekro, Cote D'ivoire
2014	6	5	16	8	42.91	6.601	-4.78		3.7			134	NDC	Toumodi/Cote D'ivoire
2014	6	6	4	38	25.69	5.523	-4.12		4.3			64	NDC	Adake, Abidjan/Cote D'ivoire
2014	6	6	22	7	22.44	12.94	1		3.9			160	NDC	Liptougou Dept/Cote D'ivoire
2014	6	10	8	27	20.43	14	0.12		4.2			119	NDC	Dori, Cote D'ivoire
2014	6	14	18	14	13.01	8.865	-4.2		3.9			110	NDC	De La Comoe, Cote D'ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2014	6	16	3	0	39.54	5.614	-5.77		3.8			82	NDC	Lakota, Cote D'ivoire
2014	6	18	23	24	2.07	6.617	-4.96		3.6			63	NDC	Toumodi/Cote D'ivoire
2014	6	29	15	52	23.7	7.794	-5.68		3.9			77	NDC	Beounm, Cote D'ivoire
2014	7	2	7	16	19.69	6.672	-4.84		4.3			83	NDC	Dimbokro, Cote D'ivoire
2014	7	3	14	28	16.21	5.28	0.46		2.5			143	NDC	Off The Coast Of Accra
2014	7	6	16	7	23.09	7.196	-3.57		3.7			141	NDC	Niado, Cote D'ivoire
2014	7	7	9	29	33.67	6.374	-6.23		4.2			177	NDC	Sinfra, Cote D'ivoire
2014	7	8	2	35	10	5.685	-3.93		3.9			24	NDC	Nsakoi, Cote D'ivoire
2014	7	11	4	36	59.87	6.493	-5.01		2.5			40	NDC	Toumodi, Cote D'ivoire
2014	7	11	22	27	15.8	11.59	1.69		4.1			96	NDC	Tapoa , Burkina Faso
2014	7	12	1	59	13.44	11.81	2.29		3.8			72	NDC	W Du Burkina Faso National Park
2014	7	12	8	22	32.61	7.661	-3.33		4.3			135	NDC	Tanda, Cote D'ivoire
2014	7	14	21	33	19.34	7.729	-5.75		4.1			80	NDC	A8, Cote D'ivoire
2014	7	17	10	46	35.61	5.88	-3.46		4.1			35	NDC	Abengourou, Cote D'ivoire
2014	7	17	13	19	0.07	7.332	-6.48		4.4			6	NDC	Vavoua, Cote D'ivoire
2014	7	18	18	42	50.18	5.569	-4.03		4.4			86	NDC	Atiekoi, Cote D'ivoire
2014	7	20	7	39	17.65	11.78	1.64		4.2			114	NDC	Tapoa , Burkina Faso
2014	7	20	10	26	38.93	5.208	-6.25		4			149	NDC	Sassandra, Cote D'Ivoire
2014	7	21	15	20	51.24	5.183	0.82		4.4			136	NDC	Off Coast Of Ada Foah, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2014	7	22	1	6	13.95	5.298	-4.57		3.9			118	NDC	Toupah, Cote D'Ivoire
2014	7	24	19	58	10.14	5.686	-0.2		3.5			149	NDC	North legon, Ghana
2014	7	26	18	13	55.6	6.377	-4.9		4.2			174	NDC	Toumodi, Cote D'Ivoire
2014	8	15	12	17	11.02	8.449	-5.81		4.2			74	NDC	Mankono Cote d' Ivoire
2014	8	15	17	46	11.02	-2.08	36.2		3.8			164	NDC	Samorosso Cote d' Ivoire
2014	8	15	19	49	14.45	3.932	-4.41		4.1			111	NDC	Gulf of Guniea
2014	8	16	1	49	57.37	13.02	-14.4		3.8			130	NDC	Fulladu East The Gambia
2014	8	19	17	37	47.48	4.643	-2.29		4.4			65	NDC	Near the coast of Axim Ghana
2014	8	24	10	33	54.71	10.54	-2.55		1.8			136	NDC	Jirapa , Upper West Ghana
2014	8	1	12	37	20.33	5.438	-3.01		4.3			42	NDC	Aboisso, Cote d' Ivoire
2014	8	1	18	16	5.27	5.926	-5.11		4.2			146	NDC	A1 Dovi, Cote d' Ivoire
2014	8	4	10	35	26.86	5.957	-4.5		4.4			62	NDC	Rubino Cote d' Lvoire
2014	9	4	6	12	43.14	7.644	-5.87		4.1			17	NDC	Zuenoula, Cote d'Ivoire
2014	9	5	11	42	43.99	6.796	-5.06		4.3			124	NDC	Toumodi, Cote d' Ivoire
2014	9	5	15	14	42.16	5.39	-5.29		4.2			90	NDC	Sud-Bandama, Cote d'Ivoire
2014	9	5	8	39	14.4	4.703	-11.9		3.5			166	NDC	North Atlantic Ocean
2014	9	8	13	55	50.4	6.188	-5.24		4.4			141	NDC	Divo , Cote d'Ivoire
2014	10	1	7	10	9.51	5.073	-2.28		4.4			52	NDC	Akanko,Western Region,Ghana
2014	10	7	0	36	46.1	5.798	-3.76		4.3			168	NDC	Near Abie,Cote d'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2014	10	10	15	37	28.37	5.314	-5.2		4.4			122	NDC	Near Divo,Cote d'Ivoire
2014	10	11	5	47	57.34	5.575	-1.57		4.5			12	NDC	Twifo-Praso,Central region,Ghana
2014	10	12	9	33	19.13	8.036	-5.1		4.5			35	NDC	Katiola,Cote d'Ivoire
2014	10	16	0	14	59.28	5.287	-4.77		4.1			121	NDC	Baie de Cosrou,Cote d'Ivoire
2014	10	20	7	26	22.83	6.507	-4.38		4.2			146	NDC	Near bongouanou, Cote d'ivoire
2014	10	22	3	23	17.4	6.863	-3.48		3.7			151	NDC	Zinzenou, Côte d'Ivoire
2014	10	23	13	25	20.93	6.673	-4.86		4.4			2	NDC	Dimbokro, Côte d'Ivoire
2014	10	30	16	39	2.89	6.283	-6.51		4.5			157	NDC	San Pedro – Betia, Côte d'Ivoire
2014	10	30	22	19	29.82	6.313	-2.26		2.5			160	NDC	Anhwieso,Western region,Ghana
2014	11	1	19	56	40	12.12	-1.35		4.2			34	NDC	Near Kombissiri,Burkina Faso
2014	11	2	2	6	26.84	5.371	-5.16		4.2			92	NDC	Near Guitri, Cote D'Ivoire
2014	11	3	17	20	31.49	6.649	-4.84		4.3			151	NDC	Dimbokro, Cote d'ivoire
2014	11	4	3	10	31.19	13.28	-1.16		4.3			128	NDC	Sanmatenga, Burkina Faso
2014	11	4	13	31	16.73	6.459	-6.79		4.1			174	NDC	Issia, Cote D'Ivoire
2014	11	4	22	24	48.13	4.715	-3.92		4.3			69	NDC	Coast off Abidjan, Cote D'Ivoire
2014	11	7	18	4	20.64	6.768	0.14		2.9			147	NDC	Aram plains near lake volta, Ghana
2014	11	7	18	29	35.03	5.803	-3.76		4.3			113	NDC	Alepe, Cote D'Ivoire
2014	11	9	16	2	11.37	4.957	-5.71		4.1			129	NDC	Sud-Bandama, Cote D'Ivoire
2014	11	11	0	0	33.27	6.491	-3.44		4			176	NDC	Abengourou, Cote D'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2014	11	15	23	49	56.59	6.657	-4.86		4			22	NDC	Dimbokro, Cote d'ivoire
2014	11	17	19	43	56.14	12.07	0.83		4.3			130	NDC	Gourma, Burkina Faso
2014	11	18	11	57	6.47	6.736	-5.4		4.5			97	NDC	Yamoussourkro, Cote D'Ivoire
2014	11	18	20	24	26.61	6.874	-5.43		4.1			121	NDC	Yamoussourkro, Cote D'Ivoire
2014	11	18	20	41	25.59	6.445	-5.19		3.2			53	NDC	Toumodi, Cote D'Ivoire
2014	11	19	16	27	54.74	6.324	-6.19		3.9			3	NDC	Gagnoa, Cote D'Ivoire
2014	11	24	17	55	29.8	3.99	-2.6		4.6			87	NDC	Off coast of Takoradi, Ghana
2014	11	26	16	57	1.81	5.896	-5.14		4.3			93	NDC	Divo, Cote D'Ivoire
2014	11	28	3	12	47.61	1.104	-6.61		4.1			120	NDC	San-Pedro, Cote D'Ivoire
2014	12	14	20	56	24.85	9.297	-2.06		4.1			117	NDC	Near Danmongo, Ghana
2014	12	14	0	27	56.28	5.553	-5.79		3.6			136	NDC	Lakota, Cote d' Ivoire
2014	12	15	16	48	19.17	7.594	-7.92		4.1			1	NDC	Near Man, Cote d'Ivoire
2014	12	22	17	32	21.48	5.08	-4.58		4.1			90	NDC	Jacqueville, Cote D'Ivoire
2014	12	23	18	50	55.77	6.684	-6.26		4.2			13	NDC	Daloa , Cote D'Ivoire
2014	12	23	22	46	14.34	5.924	-3.6		4.2			26	NDC	Adzope , Cote D'Ivoire
2014	12	24	13	22	2.75	10.02	-7.9		3.9			155	NDC	Maninian. Cote D,Ivoire
2014	12	27	10	38	10.29	14.41	-1.58		4.3			116	NDC	Sahel Reserve , Burkina Faso
2014	12	27	11	3	51.06	5.504	-4.13		4.3			121	NDC	Adake, Cote D'Ivoire
2014	12	28	12	19	43.06	8.432	0.19		3.8			136	NDC	Nkwanta, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2014	12	29	12	31	9.37	7.6	-3.83		4			144	NDC	M'bahiakro, Cote D'Ivoire
2014	12	6	0	12	51.31	5.822	-5.15		4.2			68	NDC	Ble, Cote d'Ivoire
2014	12	8	10	45	14.88	12.41	2.75		4.1			39	NDC	National Park, Karimama, Benin
2015	1	10	5	58	25.1	7.38	-0.27		4.4			152	NDC	Digya National Park,Krachi,Ghana
2015	1	11	11	1	46.23	6.464	-5		4.2			37	NDC	Toumodi, Cote d' Ivoire
2015	1	12	11	2	24.12	6.121	-5.31		4			133	NDC	Douaville, Cote d' Ivoire
2015	1	13	17	48	26.72	6.225	-6.14		4.1			160	NDC	Guiberoua, Cote d' Ivoire
2015	1	14	13	7	22.3	7.186	-7.26		3.7			12	NDC	Man, Cote d' Ivoire
2015	1	14	21	39	59.57	5.994	-6.12		3.9			152	NDC	Gagnoa, Cote d' Ivoire
2015	1	2	21	31	9.56	5.789	-4.58		4.4			84	NDC	Between Sikensi AND Ndouci
2015	1	5	10	37	0.83	13.34	-0.93		4.1			19	NDC	Kaya, Burkina Faso
2015	1	7	13	21	34.74	5.279	-5.01		3.8			48	NDC	Nzida, Cote d' Ivoire
2015	1	9	16	29	25.86	6.682	-6.24		4.1			163	NDC	Daloa, Cote d' Ivoire
2015	2	11	11	50	13	7.141	-6.11		4.3			11	NDC	Vavoua, Cote d 'Ivoire
2015	2	11	20	30	13.28	10.11	-1.11		4.2			126	NDC	Near Wiasi, Ghana
2015	2	13	21	0	46.05	6.606	-4.88		4.2			20	NDC	Toumodi, Cote d' Ivoire
2015	2	15	18	16	2.86	5.733	-5.99		4			139	NDC	Gueyo, Côte d'Ivoire
2015	2	16	9	46	11.43	8.565	5.63		3.7			152	NDC	Pategi – Egbe, Cote d' Ivoire
2015	2	19	5	29	17.4	5.519	-5.58		4.2			124	NDC	Divo, Cote D Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2015	2	19	20	3	25.2	6.656	-4.83		4.3			115	NDC	Dimbokro, Cote d'Ivoire
2015	2	22	23	45	36.02	5.138	-3.94		4.1			78	NDC	De Bassam,Côte d'Ivoire
2015	2	25	15	22	3.81	5.876	-3.71		4.3			179	NDC	Adzope, Cote D' Ivoire
2015	2	27	12	41	29.58	5.274	-5.07		2.9			109	NDC	Taboue, Cote D' Ivoire
2015	2	28	19	37	40.98	7.069	-2.59		4			158	NDC	Mim, Brong Ahafo, Ghana
2015	2	8	15	18	11.63	6.574	-5.01		4.1			57	NDC	Toumodi, Côte d'Ivoire
2015	2	8	1	29	34.58	6.155	-3.3		3.9			5	NDC	Diambarakrou, Côte d'Ivoire
2015	3	3	1	47	41.52	6.275	-3.05		3.9			164	NDC	Juabeso, Ghana
2015	3	4	2	12	49.47	12.61	1.3		3.9			104	NDC	Tapoa, Burkina Faso
2015	3	4	3	15	58.75	7.808	-4.02		4.3			109	NDC	M'bahiakro, Cote D'Ivoire
2015	3	4	12	2	7.24	5.178	-4.62		3.8			85	NDC	Jacqueville, Cote D'Ivoire
2015	3	5	0	20	55.93	6.766	-3.44		4			178	NDC	Abengourou, Cote D'Ivoire
2015	3	7	13	44	20.48	3.511	-5.78		4.3			122	NDC	Sassandra, Cote D'Ivoire
2015	3	8	13	8	7.48	7.159	-6.07		3.5			25	NDC	Marahoue National Park, Cote D'Ivoire
2015	3	10	20	55	38.48	6.511	-5.06					52	NDC	Toumodi, Cote D'Ivoire
2015	3	16	22	52	46.92	10.69	0.51		3.5			127	NDC	Kpendjal, Togo
2015	3	18	7	58	3.87	3.226	-6.95		4.1			38	NDC	Off coast of Tabou , Cote D'Ivoire
2015	3	19	4	0	36.11	11.78	1.69		3.9			97	NDC	Tapoa, Burkina Faso
2015	3	22	11	54	48.29	3.854	-7.4		4.3			112	NDC	Off coast Tabou, Cote D'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2015	3	22	15	38	8.14	3.418	-1.78		4.1			97	NDC	Off Coast Ahanta West, Ghana
2015	3	23	5	2	34.53	5.536	-5.7		3.9			30	NDC	Sud-Bandama, Cote D'Ivoire
2015	3	24	22	25	19.51	6.029	-4.38		4.5			33	NDC	Agboville, Cote D'Ivoire
2015	3	27	12	31	7.42	2.386	-2.85		4			61	NDC	Near Coast of Ghana
2015	4	13	2	34	3.01	7.266	-6.07		3.8			40	NDC	Marahoué National Park, Côte D'Ivoire
2015	4	14	8	23	23.02	14.23	-0.34		4.2			130	NDC	Sahel Reserve, Seno, Burkina Faso
2015	4	17	14	45	20.68	6.66	-4.87		4.3			61	NDC	Dimbokro, Côte D'Ivoire
2015	4	17	14	57	12.65	6.082	-5.84		4.3			147	NDC	Gagnoa, Côte D'Ivoire
2015	4	1	10	23	34.29	6.403	-7.45		4.2			74	NDC	Guiglo, Côte D'Ivoire
2015	4	1	9	52	15.01	6.667	-4.86		4.3			169	NDC	Dimbokro, Côte D'Ivoire
2015	5	10	4	6	41.86	7.989	-5.39		4.1			59	NDC	Marabadiassa, Cote D'Ivoire
2015	5	11	4	32	43.04	6.738	-4.27		4.4			132	NDC	Banabo, Cote D'Ivoire
2015	5	15	8	59	40.1	6.446	-5.17		4			47	NDC	Groudji, Cote D'Ivoire
2015	5	17	12	12	37.6	6.293	-4.72		3.9			160	NDC	Sandiemanga, Cote D'Ivoire
2015	5	18	19	9	55.4	12.48	1.38		4.4			126	NDC	Tambiga, Burkina Faso
2015	5	24	6	57	57.48	6.527	-3.86		3.6			164	NDC	Bekuefin, Cote D'Ivoire
2015	5	25	15	29	21.65	6.131	-4.81		4.5			95	NDC	Aouakro, Cote D'Ivoire
2015	5	3	10	57	47.24	4.525	2.78		2.4			40	NDC	Off coast of Porto Novo, Benin
2015	5	5	22	17	20.15	4.254	-6.88		2.7			136	NDC	San-Pedro, Cote D'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2015	5	5	2	14	57.87	6.839	-2.04		4.5			120	NDC	Domeabra, Ashanti region, Ghana
2015	5	5	20	59	52.76	7.036	-5.67		4.4			18	NDC	Tokorossou, Cote d' Ivoire
2015	5	6	9	45	46.16	5.802	-2.6		2.1			165	NDC	Gyamuro, Western region, Ghana
2015	5	8	17	32	36.25	4.358	-4.44		4			34	NDC	off coast of Grand-Bassam, Cote d' Ivoire
2015	6	4	11	5	3.82	4.482	-3.07		4.2			100	NDC	Off coast Jomoro , Ghana
2015	6	9	21	57	9.92	8.535	-4.99		4.1			63	NDC	Katiola, Cote D'Ivoire
2015	6	11	4	8	41.58	7.05	-5.41		4.3			56	NDC	Lac de Kossou , Cote D'Ivoire
2015	6	14	10	27	35.19	6.379	-4.27		4.2			46	NDC	Bongouanou, Cote D'Ivoire
2015	6	18	4	11	51.15	5.438	-0.41		4.2			148	NDC	Off coast Awutu, Ghana
2015	6	19	7	18	11.47	6.308	-3.59		4.2			16	NDC	Adzope, Cote D'Ivoire
2015	8	14	13	51	58.45	7.795	-5.73		4.3			37	NDC	Beounm, Cote D'Ivoire
2015	8	14	15	17	30.77	4.225	-5.28		4.4			119	NDC	Gulf of Guinea, Near Coast of Cote D'Ivoire
2015	8	18	13	21	25.17	6.17	-5.02		4.1			96	NDC	Tiassalé, Cote D'Ivoire
2015	8	19	8	7	16.89	6.636	-4.93		4.4			65	NDC	Dimbokro, Cote D'Ivoire
2015	8	19	19	38	52.7	5.302	-5.08		4.4			62	NDC	Sud-Bandama, Cote D'Ivoire
2015	8	22	19	38	45.6	5.546	-5.66		3.9			122	NDC	Sud-Bandama, Cote D'Ivoire
2015	8	25	3	23	34.16	12.12	0.82		4.3			131	NDC	Gourma, Burkina Faso
2015	8	28	9	33	52.57	11.58	2.75		3.9			76	NDC	Karimama, Benin
2015	8	28	19	45	6.41	6.535	-6.36		3			174	NDC	Issia, Cote D'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2015	8	3	2	49	55.07	8.07	-7.13		3.7			66	NDC	Bafing, Cote D"Ivoire
2015	9	1	0	24	8.31	6.283	-3.49		4.3			17	NDC	Adzope,cote d'voire
2015	9	1	10	0	49.97	6.506	-5.33		4.1			153	NDC	Oume,cote d'voire
2015	9	2	14	54	37.06	12.16	2.72		4.2			116	NDC	Karimama, Benin
2015	9	2	22	16	15.29	31.13	28.3		4.1			156	NDC	Mediterranean Sea
2015	9	4	10	46	46.95	12.42	2.13		4.2			33	NDC	Tapoa, Burkina faso
2015	9	8	8	35	15.4	6.458	-5.07		4.4			33	NDC	Toumodi, cote d'ivoire
2015	9	9	6	1	21.42	6.695	-4.8		4			68	NDC	Dimbokro,Cote d,ivoire
2015	9	13	3	3	53.48	5.653	-5.85		4.3			138	NDC	Lakota, Cote d'ivoire
2015	9	15	7	6	7.15	6.097	-4.44		3.7			80	NDC	Agboville, Cote d'Ivoire
2015	9	16	6	59	52.58	6.55	-6.14		3.4			176	NDC	Issia, Cote d'Ivoire
2015	9	17	17	59	44.59	12.36	0.49		4.4			144	NDC	Gourma,Burkina Faso
2015	9	18	0	8	48.77	6.302	-4.65		4.2			159	NDC	Bongouanou
2015	9	18	21	46	37.95	13.75	0.39		4.3			14	NDC	Seno, Burkina Faso
2015	9	22	11	24	16.62	5.334	-1.15		2.4			140	NDC	Abura Asebu Kwamankesse
2015	9	26	1	25	12.26	11.52	-4.78		2.2			136	NDC	Kenedougou, Burkina Faso

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2015	9	26	20	26	55.1	5.323	-5.24		4.2			121	NDC	Sud-Bandama,Cote d'Ivoire
2015	9	28	22	51	30.49	6.08	-4.46		3.9			34	NDC	Agborville, Cote d'ivoire
2015	10	2	2	3	30.44	6.438	-4.74		3.9			155	NDC	Bongouanou, Cote d'Ivoire
2015	10	6	7	54	56.31	5.302	-4.78		4.2			103	NDC	jacqueville, Cote d'Ivoire
2015	10	13	0	54	36.55	7.947	-5.09		3.9			84	NDC	Bouake,cote d'Ivoire
2015	10	31	22	20	38.61	6.696	-4.91		4			114	NDC	Dimbokro,Cote d,ivoire
2015	11	7	13	33	20.37	5.311	-4.69		4.3			76	NDC	Dabou, Côte d'Ivoire
2015	11	11	23	0	47.46	3.073	-7.1		3.9			128	NDC	Near Coast of Cote D'Ivoire
2015	11	12	18	1	27.99	11.8	1.59		4.2			106	NDC	Tapoa, Burkina Faso
2015	11	14	17	23	58.04	6.683	-5.18		4.3			29	NDC	Toumodi, Côte d'Ivoire
2015	11	18	12	55	54.27	6.79	-3.44		4.1			159	NDC	abengourou. Cote d'voire
2015	11	22	14	39	24.51	6.593	-6.29		3.7			164	NDC	Issia,cote d' voire
2015	11	22	21	47	29.22	5.873	-3.73		3.7			119	NDC	Alepe, cote d'voire
2015	11	23	7	57	59.03	17.12	-3.49		4.1			60	NDC	Goundam, Mali
2015	11	26	13	0	30.23	6.121	-4.99		4			143	NDC	tiasale, cote d'voire
2015	11	27	22	12	30.31	7.045	-4.69		4.3			114	NDC	Dimbokro, cote d' voire
2015	11	30	6	44	20.88	8.084	-4.97		4.1			94	NDC	bouake, cote d'voire
2015	11	30	23	1	42.2	7.322	-4.41		4.5			136	NDC	Daoukro, Côte d'Ivoire
2015	12	1	14	1	3.19	13.08	0.99		3.9			8	NDC	Komandjari,Burkina Faso

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2015	12	2	18	2	19.49	6.349	-4.72		4.3			159	NDC	Bongouanou,Cote D'Ivoire
2015	12	4	12	50	7.24	4.06	-4.39		4.3			98	NDC	Off the Coast of Cote d'Ivoire
2015	12	4	22	22	35.97	10.46	-4.95		3.9			171	NDC	Comoe,Burkina Faso
2015	12	8	21	34	0.51	5.3	-5.14		4			122	NDC	Sud-Bandama,Cote D'Ivoire
2015	12	11	20	16	28.05	5.429	-4.26		4.3			109	NDC	Abidjan, Cote D'Ivoire
2015	12	14	2	0	41.54	13.7	0.37		4			18	NDC	Yagha,Burkina Faso
2015	12	14	7	30	12.61	6.266	-4.14		4.2			18	NDC	Agnebi,Cote D'Ivoire
2015	12	14	21	41	25.99	7.207	-3.58		4			140	NDC	Agnibilekrou,Cote D'Ivoire
2015	12	18	9	56	19.82	12.4	1.2		3.8			127	NDC	Tapoa,Burkina Faso
2015	12	18	21	58	52.66	13.21	0.79		4.3			3	NDC	Yagha,Burkina Faso
2015	12	19	16	29	17.65	12.87	-3.86		3.7			153	NDC	Kossi,Burkina Faso
2015	12	19	23	20	13.55	5.472	-5.49		4.1			121	NDC	Sud-Bandama,Cote D'Ivoire
2015	12	24	23	57	55.34	4.448	-0.69		4.2			57	NDC	Off the Coast of Ghana
2015	12	27	17	37	28.6	6.525	-5.32		4.4			167	NDC	Toumodi,Cote d'Ivoire
2016	1	4	17	21	27.38	7.905	-5.52		3.9			26	NDC	Beoumi,Cote d'voire
2016	1	7	15	55	53.35	8.641	-4.99		4.3			100	NDC	Katiola,cote d'voire
2016	1	7	22	29	6.7	13.9	0.37		4.4			35	NDC	Seno,Burkina Faso
2016	1	10	14	22	48.43	4.257	0.08		4			136	NDC	Off the coast of Accra Ghana
2016	1	10	15	49	43.76	5.624	0.86		4.2			141	NDC	Off the coast of Accra Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2016	1	10	21	38	23.91	12.24	0.61		4.2			142	NDC	Gourma,Burkina Faso
2016	1	16	2	44	47.93	14.22	-1.19		2.1			164	NDC	Soum,Burkina Faso
2016	1	17	15	35	11.41	10.14	2.76		4			120	NDC	Bembereke, Benin
2016	1	18	2	27	19.64	34.77	-5.25		4.1			120	NDC	Chefchaouen,Morocco
2016	1	19	12	5	15.72	7.346	-6.17		3.2			34	NDC	Zuenoula, Cote d'Ivoire
2016	1	26	11	6	10.5	7.653	-0.28		2.7			136	NDC	Lake Volta,Ghana
2016	1	26	12	47	32.26	5.474	-5.29		4.4			113	NDC	Sud-Bandama, Cote d'iovoire
2016	1	26	22	45	21.95	9.482	-7.9		2.1			108	NDC	Denguele,Cote d'Ivoire
2016	1	27	14	7	57.85	8.993	-5.96		4.1			76	NDC	Khorogo,Cote d'Ivoire
2016	1	28	11	13	38.71	4.146	-5.25		4.2			86	NDC	Off The Coast of Cote d'ivoire
2016	2	2	12	44	33.04	7.619	-4.27		4.2			119	NDC	M'bahiakro, Cote D'Ivoire
2016	2	3	8	29	38.28	7.769	-5.38		4.2			69	NDC	Beoumi, Cote D'Ivoire
2016	2	6	13	49	47.53	5.262	-5.1		4.1			113	NDC	Sud-Bandama, Cote d'Ivoire
2016	2	8	19	33	11.2	7.973	-5.57		4			64	NDC	Beoumi, Cote D'Ivoire
2016	2	8	20	25	49.17	6.037	-4.82		4.3			99	NDC	Tiassale, Cote d'Ivoire
2016	2	9	16	59	45.4	0.628	-5.51		3.9			128	NDC	Near Abidjan, Cote d'Ivoire
2016	2	9	22	33	26.77	11.29	1.75		4.4			99	NDC	Tanguieta, Benin
2016	2	10	1	42	34.51	14.32	0.11		3.5			50	NDC	Oudalan, Burkina Faso
2016	2	18	1	17	21.98	7.006	-2.37		4.3			157	NDC	Hwidiem Kumasi, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2016	2	20	13	10	13.97	12.79	0.93		4.4			151	NDC	Komandjari, Burkina Faso
2016	3	7	5	16	3.93	5.282	-4.72		4.3			139	NDC	Dabou,Cote D'Ivoire
2016	3	10	9	17	31.83	5.7	-3.31		4			26	NDC	Aboiso,Cote d'Ivoire
2016	3	13	8	8	39.28	4.725	-5.17		4			112	NDC	Off The Coast Of Cote d'Ivoire
2016	3	13	11	59	29.97	7.628	-5.16		3.8			66	NDC	Sakassou,Cote d'Ivoire
2016	3	18	18	19	27.86	6.313	-5.77		4.3			168	NDC	Gagnoa,Cote d'Ivoire
2016	3	19	9	17	70.85	10.68	-4.27		4			163	NDC	Comoe,Burkina Faso
2016	3	25	13	10	20.1	3.303	-2.96		4.3			104	NDC	Off The Coast Of Cote d'Ivoire
2016	3	26	18	34	49.65	7.549	-1.42		4.1			122	NDC	Ejura,Ghana
2016	4	2	11	55	11.71	4.178	-3.67		3.8			111	NDC	Near Coast of Cote D'Ivoire
2016	4	3	23	24	17.51	6.907	-5.42		4.2			36	NDC	Yamoussourkro, Cote D'Ivoire
2016	4	5	23	52	14.8	6.007	-2.16		2.6			161	NDC	Near Diaso, Ashanti Region, Ghana
2016	4	6	17	9	12.78	5.466	-3.37		4.1			63	NDC	Aboisso, Cote D'Ivoire
2016	4	11	23	36	35.03	9.857	-3.38		3.7			128	NDC	Bouna, Cote D'Ivoire
2016	4	16	9	48	25.73	11.76	1.89		4.3			110	NDC	Tapoa, Burkina Faso
2016	4	16	12	58	34.12	7.005	-2.15		2.4			155	NDC	Tepa, Ashanti Region, Ghana
2016	4	17	11	51	56.35	8.3	-3.21		4.3			135	NDC	Bondoukou, Cote D'Ivoire
2016	4	22	10	28	42.55	5.342	-5.26		3.4			114	NDC	Sud- Bandama, Cote D'Ivoire
2016	4	22	13	48	28.43	6.006	-5.3		4.2			87	NDC	Divo, Cote D'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2016	4	24	17	49	30.5	6.569	-4.54		4.1			10	NDC	Dimtokros,Cote D'Ivoire
2016	4	25	19	55	59.61	5.934	-7.39		2.4			155	NDC	Guiglo, Cote D'Ivoire
2016	4	26	2	46	48.82	7.279	-5.62		4.1			47	NDC	Tiebissou Dept, Cote D'Ivoire
2016	4	26	5	18	49.75	6.58	-4.88		3.6			16	NDC	Toumodi, Cote D'Ivoire
2016	4	27	6	52	23.95	12.8	0.92		4.4			154	NDC	Komandjari, Burkina Faso
2016	5	3	6	10	13.9	6.806	-5.09		4.1			123	NDC	Toumodi, Cote D' I voire
2016	5	4	9	21	47.76	5.379	-5.75		4.4			129	NDC	Sud-bandama, Cote d'Voire
2016	5	4	19	37	16.38	13.32	0.28		4.3			169	NDC	Yagha, Burkina Faso
2016	5	8	12	39	24.66	6.792	-3.84		4.2			168	NDC	Bougouanou, cote d'Ivoire
2016	5	8	21	49	35.11	6.044	2.63		4.4			155	NDC	Near Cotonou,Benin
2016	5	9	2	5	25.6	12.73	0.2		4			162	NDC	Gnagna,Burkina Faso
2016	5	10	13	2	26.33	8.073	-5.16		4.3			85	NDC	Bouake, Cote d'Ivoire
2016	5	19	5	17	4.2	12.62	1.89		4.3			4	NDC	Tapoa , Burkina Faso
2016	5	25	6	46	41.96	6.303	-5.1		4.2			152	NDC	Toumodi, Cote D' I voire
2016	5	25	16	13	2.06	6.07	-4.29		4			43	NDC	Agboville, cote d'Ivoire
2016	5	27	4	25	28.49	30.09	-1.31		4.3			121	NDC	Gnagna,Burkina Faso
2016	5	27	12	46	3.16	13.26	-1.48		3			157	NDC	Bam, Burkina Faso
2016	5	28	5	58	23.94	7.587	-3.46		4.9			40	NDC	Tanda, cote d'ivoire
2016	5	28	12	39	2.44	12.23	0.64		4.2			142	NDC	Gourma, Burkina Faso

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2016	5	30	11	48	11.29	6.631	-4.86		4.4			9	NDC	Dimbokro,Cote d ivoire
2016	6	1	23	25	52.62	6.443	-6.25		4.4			10	NDC	Issia, Cote d'ivoire
2016	6	5	20	33	22.29	5.628	-5.74		4.1			154	NDC	Lakota, Cote d'ivoire
2016	6	10	4	58	22.86	8.691	-5.58		2.8			101	NDC	Katiola,Cote d'Ivoire
2016	6	11	19	16	16.16	7.729	0.06		2.3			16	NDC	Lake volta,Ghana
2016	6	13	20	45	23.9	4.337	-5.46		4.2			129	NDC	Near Coast of Cote d'Ivoire
2016	6	13	21	17	42.62	6.703	-5.72		4.4			173	NDC	Sinfra, Cote d'Ivoire
2016	6	21	17	53	20.04	5.504	-5.59		3.6			120	NDC	Sud- Bandama, Cote d'Ivoire
2016	6	21	22	40	40.63	12.17	2.71		4			115	NDC	Karimama, Benin
2016	6	23	10	45	12.83	7.494	-4.97		4.1			73	NDC	Bouake, Cote d'Ivoire
2016	6	23	18	47	12.6	4.942	-3.37		4			29	NDC	Near Coast of Abidjan
2016	6	24	3	18	23.31	6.55	-6.3		4.5			167	NDC	Issia, Cote d'ivoire
2016	7	1	12	35	30.77	-28.6	25.1		3.9			101	NDC	Near Coast of Cape Coast
2016	7	3	16	18	49.01	13.49	-1.63		2			148	NDC	Bam, Burkina Faso
2016	7	4	5	0	2.62	12.29	0.59		3.8			125	NDC	Gourma, Burkina Faso
2016	7	12	0	50	46.46	6.665	-3.86		4.2			150	NDC	Nzi-Comoe, Cote D'Ivoire
2016	7	15	0	1	40.81	6.389	-6.06		4			170	NDC	Gagnoa, Cote d'Ivoire
2016	7	16	18	38	7.37	7.191	-6.34		4.1			17	NDC	Daloa, Cote d'Ivoire
2016	7	26	20	25	36.64	5.332	-4.6		4.2			81	NDC	Lagunes, Cote d'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2016	7	30	23	49	27.54	7.265	-5.61		3.8			68	NDC	Tiebissou Department, Cote d'Ivoire
2016	7	31	21	26	20.6	6.62	-4.77		4.2			119	NDC	Dimbokro, Cote d'Ivoire
2016	8	2	17	56	5.78	6.722	-3.81		4.3			9	NDC	Bongouanou, Cote d'Ivoire
2016	8	5	23	18	29.29	6.277	-4.44		4.4			58	NDC	Bongouanou, Cote d'Ivoire
2016	8	7	22	39	31.52	6.304	-3.45		4.1			11	NDC	Abengourou, Cote d'Ivoire
2016	8	12	1	48	4	13.98	0.21		4.3			110	NDC	Seno, Burkina Faso
2016	8	12	19	14	12.85	12.23	2.02		4			152	NDC	Burkina Faso National Park
2016	8	13	6	54	32.97	6.662	-4.79		3.9			97	NDC	Dimbokro, Cote d'Ivoire
2016	8	17	18	52	23.65	5.771	-5.9		4.4			149	NDC	Lakota, Cote d'Ivoire
2016	8	18	11	42	51.65	13.04	0.27		4.2			168	NDC	Gnagna, Burkina Faso
2016	8	20	20	15	10.23	10.34	-2.51		3.7			134	NDC	Nadowli,Wa, Upper West, Ghana
2016	8	23	16	9	54.47	5.381	-4.26		4.4			64	NDC	Abidjan, Cote d'Ivoire
2016	8	24	15	29	43.2	-27.3	28.3		2.4			150	NDC	Frankfort, South Africa
2016	8	25	5	35	32.14	7.064	-6.31		4.3			14	NDC	Daloa, Cote d'Ivoire
2016	8	26	10	57	10.45	5.913	-6.02		4.2			171	NDC	Gagnoa, Cote d'Ivoire
2016	8	29	12	46	42.25	6.761	-5.4		4			27	NDC	Yamoussourkro, Cote d'Ivoire
2016	9	2	20	37	4.45	6.571	-5.39		3.2			43	NDC	Oume, Cote d'Ivoire
2016	9	3	17	26	21.6	7.558	-3.76		3.7			135	NDC	M'bahiakro, Cote d'Ivoire
2016	9	4	4	16	58.04	6.648	-6.82		3.4			23	NDC	Haut- Sassandra, Cote d'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2016	9	5	22	36	2.17	8.016	-5.22		4.4			83	NDC	Bouake, Cote d' Ivoire
2016	9	14	9	20	47.11	6.75	-6.28		4			15	NDC	Daloa,Cote d'Ivoire
2016	9	24	14	20	46.22	12.3	-2.48		4.1			162	NDC	Sanguie, Burkina Faso
2016	9	24	22	15	8.66	12.6	-1.44		2.1			170	NDC	Oubritenga, Burkina Faso
2016	9	26	22	15	54.66	12.76	1.35		4.3			129	NDC	Tapoa, Burkina Faso
2016	9	29	1	54	5.96	5.301	-5.09		4			119	NDC	Sud-Bandama, Cote D'Ivoire
2016	10	9	20	46	46.56	7.984	-4.42		4			71	NDC	Dabakala, Cote d'lvoire
2016	10	12	17	57	36.02	6.199	-4.59		4.4			2	NDC	Tiassale, Cote d'lvoire
2016	10	14	2	4	54.2	9.019	-4.31		1.9			123	NDC	Ferkessedougou, Cote d'lvoire
2016	11	1	17	54	57.81	8.057	-4.64		4.3			104	NDC	Dabakala, Cote d'lvoire
2016	11	6	15	58	53.53	12.73	0.35		4.2			131	NDC	Komandjari,Burkina Faso
2016	11	8	16	7	32.35	9.877	-3.78		1.9			122	NDC	Bouna,Cote d'Ivoire
2016	11	15	16	49	33.88	6.438	-4.29		3.4			24	NDC	Bongouanou,Cote d'Ivoire
2016	11	16	4	9	40.36	5.475	-3.05		2.8			178	NDC	Aboisso, Cote d'Ivoire
2016	11	19	7	24	24.82	6.379	-6.2		4			8	NDC	Issia, Cote D'Ivoire
2016	11	20	17	7	58.93	6.756	-4.85		4.1			1	NDC	Dimbokro, Cote D'Ivoire
2016	11	21	2	16	47.7	12.37	2.87		4.3			59	NDC	Karimama, Benin
2016	12	3	22	37	25.15	5.4	-5.38		4.1			89	NDC	Sud-Bandana, Cote d'Ivoire
2016	12	6	17	7	21.58	6.424	-5.74		4.3			160	NDC	Oume, Cote d'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2016	12	7	13	7	12.09	5.316	-5.1		4.2			116	NDC	Sud-Bandana, Cote D'Ivoire
2016	12	12	5	26	14.24	7.355	-3.56		4			147	NDC	Daoukro, Cote D'Ivoire
2016	12	13	6	12	12.09	7.471	-3.74		4.1			140	NDC	Nzi-Comoe, Cote D'Ivore
2016	12	18	7	52	57.57	13.6	-2.78		3.8			19	NDC	Yatenga, Burkina Faso
2016	12	19	13	15	2.83	6.314	-4.54		3.9			56	NDC	Bongouanou, Cote D'Ivoire
2016	12	20	4	3	33.49	6.254	-6.25		4.4			170	NDC	Gagnoa, Cote D'Ivoire
2016	12	22	17	36	40.62	6.889	-5.99		3.4			35	NDC	Bouafle, Cote D'Ivoire
2016	12	31	22	4	3.19	5.616	-3.96		4.1			18	NDC	Abidjan, Cote D'Ivoire
2017	1	1	20	56	15	6.309	0.87	13	1.5				GGSA	Ave Xevi, Volta Region, Ghana
2017	1	13	21	37	37.17	13.4	-0.17		4.3			169	NDC	Gnagna, Burkina Faso
2017	1	19	5	41	35.87	6.611	-6.31		3.4			2	NDC	Issia, Cote d'Ivoire
2017	1	22	21	16	38.63	13.08	-3.55		4			106	NDC	Kossi, Burkina Faso
2017	1	23	5	11	28.6	6.961	-6.25		4.1			20	NDC	Daloa, Cote d'lvoire
2017	1	23	12	37	14.97	6.559	-4.8		4.3			154	NDC	Toumodi,Cote d'Ivoire
2017	1	24	21	16	32.25	6.182	-2.73		1.4			162	NDC	Boin National Park, Essase, Ghana
2017	1	26	1	19	50.59	5.805	-3.77		3.9			173	NDC	Alepe, Cote d'lvoire
2017	1	26	21	52	58.13	7.134	-3.55		3.7			143	NDC	Agnibilekrou, Cote d'lvoire
2017	1	28	3	7	15.35	5.334	-5.37		3.8			111	NDC	Sud-Bandama, Cote d'lvoire
2017	1	30	19	26	38.36	6.659	-4.85		3.9			169	NDC	Dimbokro, Cote d'lvoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2017	2	8	0	22	40.67	4.54	-2.91		4.1			137	NDC	Near Coast of Ahobre, Ghana
2017	3	19	16	53	53	6.241	0.16	7	2.5				GGSA	R24, Volo, Volta Region, Ghana
2017	3	19	23	38	41.33	6.092	-7.21		2.5			137	NDC	Guiglo, Cote d'Ivoire
2017	3	20	9	35	26	6.155	0.53	0	2				GGSA	Mafi Dadoboe, Volta Region, Ghana
2017	3	21	9	0	51	6.172	0.4	6	2.2				GGSA	Jasikan, V/R, Ghana
2017	3	21	16	48	45	6.016	0.63	51	2.5				GGSA	Hlevi, South Tougu, V/R, Ghana
2017	3	22	8	28	55	6.275	0.04	5.5	2.1				GGSA	Akosombo, E/R, Ghana
2017	3	22	21	45	2.94	6.431	-6.22		4.2			161	NDC	Issia, Cote d'Ivoire
2017	3	26	10	35	43	6.259	0.11	4.8	3.4				GGSA	Atimpoku, V/R, Ghana
2017	3	26	13	29	8.07	9.036	-3.54		4.3			111	NDC	Bouna, Cote d'Ivoire
2017	3	28	12	44	18.73	7.263	-3.58		4.4			14	NDC	Agnibilekrou, Cote d'lvoire
2017	3	29	5	53	44.13	7.287	-5.54		4.1			42	NDC	Tiebissou Department, Cote d'Ivoire
2017	3	31	5	55	16	6.311	0.02	24	2.6				GGSA	Akosombo, E/R, Ghana
2017	3	31	18	6	33	6.457	0.47	0	2.8				GGSA	Adaklu Sikama, V/R, Ghana
2017	4	3	4	23	58.63	6.027	-3.63		3.8			176	NDC	Adzope, Cote d'lvoire
2017	4	8	17	54	7.58	8.496	-2.32		3.9			125	NDC	Bole, Ghana
2017	4	9	0	31	47.63	6.651	-4.94		4			78	NDC	Toumodi,Cote d'Ivoire
2017	4	9	2	20	52.1	6.024	-2.44		3.7			165	NDC	Sefwi-Wiawso, Ghana
2017	4	9	3	51	4.6	6.767	-4.53		4.2			75	NDC	Dimtokros, Cote dlvoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2017	4	10	14	27	37.26	5.622	-5.83		4			134	NDC	Lakota, Cote dlvoire
2017	4	13	23	51	16.09	6.667	-4.85		3.6			117	NDC	Dimbokro, Cote d'lvoire
2017	4	14	7	0	18.27	6.657	-6.15		3.5			3	NDC	Issia, Cote d'Ivoire
2017	4	15	8	30	6.82	5.749	-3.42		4.4			5	NDC	Aboisso, Cote dlvoire
2017	4	17	7	28	56	5.715	0.22	7.1	3.5				GGSA	Northern Region, Ghana
2017	4	22	15	1	32	6.071	0.24	4.6	3.4				GGSA	Dangma West, E/R, Ghana
2017	4	26	14	30	37	6.266	0.45	4.7	3.8				GGSA	Jasikan, V/R, Ghana
2017	4	28	5	38	48	6.182	0.06	3.8	3.8				GGSA	Kpong, Eastern Region, Ghana
2017	4	29	16	0	34	6.043	0.19	9.8	2.1				GGSA	Fanteakwa, E/R, Ghana
2017	4	30	7	23	48	6.107	0.3	35	3.5				GGSA	Volo, North Tongu, V/R, Ghana
2017	5	3	15	52	42	5.867	0.02	2.9	3.6				GGSA	Manya-Jorpanya, Ghana
2017	5	6	14	46	8	6.037	1.13	12	3.7				GGSA	Adafienu, Volta Region, Ghana
2017	5	7	11	11	28.97	1.723	-0.16		2.2			63	NDC	near coast of Takoradi, Ghana
2017	5	7	16	42	0.03	4.792	-4.99		4			93	NDC	Off the Coast of Cote D'Ivoire
2017	5	7	21	14	48.87	12.09	2.75		3.9			43	NDC	Karimama, Benin
2017	5	10	11	42	43.09	6.6112	-6.26		4			167	NDC	Haut- Sassandra, Cote D'Ivoire
2017	5	10	17	52	45.07	5.7477	-5.6346		4.4			133	NDC	Lakota, Cote D’Ivoire
2017	5	11	14	15	36.22	6.266	-3.38		4.3			21	NDC	Abengourou, Cote D'Ivoire
2017	5	11	19	20	1.77	5.49	-5.83		4.2			128	NDC	Bas-Sassandra Region, Cote D'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2017	5	13	15	2	2	6.394	0.8	3.9	3.2				GGSA	Dzodze, V/R, Ghana
2017	5	14	16	15	14.77	6.1320	-5.25		4.3			101	NDC	Divo, Cote D'Ivoire
2017	5	18	12	39	57	6.845	0.56	4.8	1.9				GGSA	Mayondi, Togo
2017	5	22	15	24	21	6.427	1.01	1.8	3.8				GGSA	Zogbépime, Togo
2017	5	23	16	2	37	5.774	1.14	7.9	3.4				GGSA	Northern Region, Ghana
2017	5	24	12	54	5	6.24	0.14	3.2	3.4				GGSA	Juapong, V/R, Ghana
2017	5	25	15	47	24	6.192	0.37	0.4	2.4				GGSA	Jasikan, V/R, Ghana
2017	5	28	16	20	27	5.64	0.25	3.6	2.2				GGSA	Northern Region, Ghana
2017	6	3	9	26	21.02	14	-2.12		4.3			148	NDC	Loroum, Burkina Faso
2017	6	3	15	57	27	5.981	0.22	3.8	3.9				GGSA	Tsopoli, Dangme West, Ghana
2017	6	4	13	46	17	5.901	0.06	2.6	2.9				GGSA	Manya, Damgme West, Ghana
2017	6	6	16	52	51	5.98	0.29	4.8	3.9				GGSA	Damgme West, Ghana
2017	6	8	16	9	31	6.353	1	8.9	3.5				GGSA	Route Lomé, Kpalimé Bagbé, Togo
2017	6	9	16	58	6	5.376	0.47	32	3.9				GGSA	Gulf of Guinea, Ghana
2017	6	11	14	40	19	6.332	1.04	0.1	3.3				GGSA	Kovié, Region Maritime, Togo
2017	7	3	13	52	21.2	14.69	-0.11		4.2			63	NDC	Oudalan, Burkina Faso
2017	10	13	2	46	47.53	6.745	-6.31		4.2			178	NDC	Daloa, Côte d'Ivoire
2017	10	18	15	5	46.26	11.49	-3.25		2.3			135	NDC	Bale,Burkina-Faso
2017	10	18	17	26	38.58	6.849	-2.69		4.2			4	NDC	Asunafo North, Ghana

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2017	10	22	22	13	45.82	6.836	-2.22		1.6			150	NDC	Near Abawdiem, Ashanti Region
2017	11	3	22	53	52.1	6.579	-5.02		4.3			59	NDC	Near Toumodi, Cote D'Ivoire
2017	11	6	4	37	11.42	7.091	-6.14		4			176	NDC	de Marahoue,Cote D'Ivoire
2017	11	7	9	18	31.59	11.18	2.22		4.4			123	NDC	Goumori, Benin
2017	11	9	6	36	59.5	7.853	-4.1		4.4			117	NDC	Groumania, Cote D'Ivoire
2017	11	9	6	39	34.45	5.634	-5.82		2.3			135	NDC	Gague, Cote D'Ivoire
2017	11	9	6	50	56.86	14.8	-5.89		4.1			145	NDC	Massabougou, Mali
2017	11	23	14	16	23.59	5.735	-6.28		4.4			149	NDC	Near Guedeyo I, Cote d'Ivoire
2017	12	1	13	42	3.47	6.12	-6.16		4.5			151	NDC	Near Bogrenyoa, Cote D'Ivoire
2017	12	2	1	33	43.66	5.619	-5.69		3.9			133	NDC	Gague, Cote D'Ivoire
2017	12	5	23	42	52.3	13.17	0.33		4.3			179	NDC	Near Liptougou, Burkina Faso
2017	12	10	21	11	2.21	6.414	-4.06		3.9			14	NDC	Near Akoupe, Cote D'Ivoire
2017	12	13	12	12	6.85	13.56	-0.26		4.2			179	NDC	Near Bani, Burkina Faso
2017	12	18	15	37	43.4	13.65	0.34		4.2			26	NDC	Near Aligaga, Burkina Faso
2017	12	18	18	9	20.12	5.854	-3.71		2.8			14	NDC	Near Kossandji, Cote d'Ivoire
2017	12	19	23	1	38.41	6.997	-6.49		4.3			176	NDC	Near Brizeboua, Cote D'Ivoire
2017	12	21	19	51	45.21	7.386	-6.13		4.5			28	NDC	Near Zueoula, Cote D'Ivoire
2018	1	2	16	58	14.22	11.89	1.31		4.2			107	NDC	Near Singou Reserve, Burkina Faso
2018	1	3	22	45	39.8	8.55	-6.28		4.1			80	NDC	Near Faraba, Cote D'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2018	1	5	0	49	40.76	13.32	0.32		3.9			172	NDC	Near Fouga, Burkina Faso
2018	1	13	0	53	16.94	5.938	-1.49		4			163	NDC	Near Krodua, Ghana
2018	1	14	8	41	42.67	13.1	0.32		3.6			3	NDC	Near Kokou, Burkina Faso
2018	1	17	9	28	34.81	10.93	-1.92		4.1			134	NDC	Sissala East, Kasapouli, Ghana
2018	1	20	19	10	14.37	10.06	-1.7		4.1			133	NDC	Mole National Park, Ghana
2018	1	22	6	50	14.96	6.668	-5.44		4			83	NDC	Near Bazai, Cote D'Ivoire
2018	1	22	18	23	24.85	4.948	-5.81		4.2			112	NDC	Off the Coast of Cote D'Ivoire
2018	1	22	23	33	37.33	6.583	-6.24		4.1			30	NDC	Saoula, Cote D'Ivoire
2018	1	24	19	28	18.74	5.405	-4.34		4			54	NDC	Orgaff, Cote D'Ivoire
2018	1	27	8	34	36.81	7.378	-7.35		3.6			20	NDC	Near Man, Cote D'Ivoire
2018	1	29	5	51	32.89	6.495	-5.35		3.9			70	NDC	Zangue, Cote D'Ivoire
2018	2	2	19	2	57.13	6.832	-3.97		4			175	NDC	Arrah, Cote D'Ivoire
2018	2	3	13	37	6.55	7.134	-4.7		3.7			10	NDC	Mekro, Cote D'Ivoire
2018	2	4	22	29	21.82	5.678	-3.2		3.9			24	NDC	Bia River, Cote D'Ivoire
2018	2	6	16	40	3.38	12.97	0.95		4.3			156	NDC	Bossongri, Burkina Faso
2018	2	10	15	41	14.75	6.319	-3.99		4.1			30	NDC	Affrey, Cote D'Ivoire
2018	2	10	21	31	46.52	5.381	-5.41		4.1			120	NDC	Niakro, Cote D'Ivoire
2018	2	10	23	19	22.3	5.882	-3.71		4.2			48	NDC	Kossandji, Cote D'Ivoire
2018	2	14	8	49	5.38	9.293	-5.25		4.3			91	NDC	Badikaha, Cote D'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2018	2	15	8	30	58.12	6.527	-5.5		4.4			0	NDC	Zangue, Cote D'Ivoire
2018	2	19	16	4	52.33	11.97	-1.84		3.3			139	NDC	Singdin, Burkina Faso
2018	2	28	3	15	54.49	5.327	-4.48		3.9			78	NDC	Mopoyeme, Cote D'Ivoire
2018	3	1	3	36	31.16	5.795	-3.76		4.2			45	NDC	Kossandji, Cote D'Ivoire
2018	3	2	11	46	8	6.968	-5.68		4.2			17	NDC	Bouafle, Cote D'Ivoire
2018	3	4	12	51	35.26	6.271	-6.23		3.8			162	NDC	Basi, Cote D'Ivoire
2018	3	5	5	29	1.24	9.418	-7.26		4			118	NDC	Tieme, Cote D'Ivoire
2018	3	6	4	51	8.32	6.649	-4.84		4.4			134	NDC	Dimbokro, Cote D'Ivoire
2018	3	8	5	43	8.81	6.08	-3.59		3.8			1	NDC	Biebi, Cote D'Ivoire
2018	3	10	5	42	37.05	5.278	-5.07		4			114	NDC	Taboue, Cote D'Ivoire
2018	3	12	9	42	4.69	12.05	1.09		3.8			114	NDC	Singou Reserve, Burkina Faso
2018	3	22	3	47	7.99	5.306	-5.15		4.5			113	NDC	Sud-Bandama, Cote D'Ivoire
2018	3	24	3	9	43	5.594	-0.31	6.6	2.8				GGSA	Near Anyaa, Accra
2018	3	24	3	41	26	5.556	-0.3	9.4	3.30				GGSA	Near Mendskrom, Accra
2018	3	24	11	31	34	5.577	-0.29	8.6	3.00				GGSA	Near Sakumo, Accra
2018	3	24	14	56	19.36	7.998	-4.78		4.3			98	NDC	Bouaké, Cote D'Ivoire
2018	3	24	20	28	35.38	6.296	-4.7		4.1			152	NDC	Bongouanou, Cote D'Ivoire
2018	3	26	12	0	17.96	12.91	0.14		3.9			171	NDC	Gnagna, Burkina Faso
2018	3	28	17	51	9.63	5.291	-4.65		4.2			58	NDC	Dabou, Cote D'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2018	3	29	4	35	17.31	6.668	-3.5		4.1			161	NDC	Abengourou, Cote D'Ivoire
2018	4	3	6	41	55.79	5.497	-5.46		4.3			117	NDC	Sud-Bandama, Cote D'Ivoire
2018	4	3	17	6	3.29	5.677	-5.81		3.9			135	NDC	Lakota, Cote D'Ivoire
2018	4	4	20	0	27.92	6.818	-3.51		4.3			179	NDC	Abengourou, Cote D'Ivoire
2018	4	4	21	56	5.09	7.114	-4.44		4.1			135	NDC	Salé-Balékro,Cote D'Ivoire
2018	4	6	14	14	58.95	12.06	-1.73		4.1			158	NDC	Kadiogo, Burkina Faso
2018	4	8	14	0	16.98	6.481	-5.6		3.9			157	NDC	Oume, Cote D'Ivoire
2018	4	9	0	30	42.78	8.506	-2.09		4.4			138	NDC	Bole, Ghana
2018	4	13	18	28	18.02	7.311	-4.18		4.5			170	NDC	Daoukro, Cote D'Ivoire
2018	4	13	19	31	16.54	7.731	-5.75		4.3			66	NDC	Beounm, Cote D'Ivoire
2018	4	15	17	55	41.95	13.64	-1.68		4			179	NDC	Bam, Burkina Faso
2018	4	18	12	44	11.72	7.434	-6.09		4.2			39	NDC	Baazra, Cote D'Ivoire
2018	4	21	17	15	14.97	13.3	0.97		2.7			133	NDC	Yagha, Burkina Faso
2018	4	22	2	45	9.64	7.191	-4.61		3.8			121	NDC	Mekro, Cote D'Ivoire
2018	4	23	4	10	52.83	5.338	-4.46		4			113	NDC	Bouboury, Cote D'Ivoire
2018	4	23	7	57	4.23	6.895	-3.5		3.9			155	NDC	Zinzenou, Cote D'Ivoire
2018	4	23	13	4	50.14	5.788	-3.03		4			7	NDC	Ebikro, Cote D'Ivoire
2018	4	23	17	31	12.63	11.89	2.32		4			32	NDC	W du Burkina Faso Natoional Park
2018	4	27	3	45	58.76	6.045	-6.14		4.1			157	NDC	Bakeyo, Cote D'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2018	4	27	4	40	39.49	11.99	-2.88		4.3			130	NDC	Seyou, Cote D'Ivoire
2018	4	30	15	45	3.26	6.062	-5.24		3.9			11	NDC	Zehiri, Cote D'Ivoire
2018	4	30	22	24	57.52	7.772	-6.94		3.8			37	NDC	Babien, Cote D'Ivoire
2018	5	2	15	24	19	12.27	1.31		4.2			108	NDC	Tapoa, Burkina Faso
2018	5	4	8	26	30.31	12.09	2.47		4.3			45	NDC	Karimama, Benin
2018	5	8	18	5	37.71	6.65	-4.98		4.1			81	NDC	Toumodi, Cote D'Ivoire
2018	5	11	5	6	18.22	5.238	-4.94		4.4			97	NDC	Agouaye, Cote D'Ivoire
2018	5	11	8	35	37.73	6.626	-4.78		4.3			120	NDC	Krokro, Cote D'Ivoire
2018	5	14	16	33	23.24	7.054	-5.23		4.3			166	NDC	Gbomi Kondeyaokro, Cote D'Ivoire
2018	5	16	5	30	27.1	13.12	0.72		3.6			22	NDC	Babonga, Burkina Faso
2018	5	17	4	33	22.96	12.53	1.92		4.3			87	NDC	Kahel, Burkina Faso
2018	5	18	16	17	29.11	6.675	-6.22		4.2			178	NDC	Zagoreta, Cote D'Ivoire
2018	5	22	20	27	28.16	12.13	0.68		4.4			137	NDC	Gourma, Burkina Faso
2018	5	23	10	43	24.62	6.042	-6.13		3.7			156	NDC	Gagnoa, Ivory Coast
2018	5	25	0	20	35.33	6.307	-6.67		3.6			178	NDC	Issia, Ivory Coast
2018	6	2	15	52	16.04	5.361	-4.33		4			88	NDC	Near Debrimou, Cote D'Ivoire
2018	6	4	19	11	18.12	7.189	-7.46		4.2			176	NDC	Near Gebe , Cote D'Ivoire
2018	6	5	3	19	31.19	13.65	0.54		3.9			24	NDC	Near Tyena,Burkina Faso
2018	6	6	17	46	27.51	6.304	-6.08		3.6			164	NDC	Near Basi, Cote D'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2018	6	8	12	44	2.47	6.073	-3.53		4.3			28	NDC	Near Bettie , Cote D'Ivoire
2018	6	9	22	35	9.24	-0.16	-4.45		4.3			117	NDC	Off the coast of Cote D'Ivoire
2018	6	10	7	26	33.17	6.55	-4.95		4			36	NDC	Near Toumodi , Cote D'Ivoire
2018	6	10	17	11	36.44	0.928	-0.14		3.8			131	NDC	Off the coast of Ghana
2018	6	12	3	31	7.32	7.145	-5.59		4.3			32	NDC	Near Molonou, Ivory Coast
2018	6	12	20	9	1.36	6.914	-6.91		4.3			176	NDC	Near Marahoue, Ivory coast
2018	6	14	18	19	26.9	9.698	2.23		4.4			20	NDC	Near Sonoumon, B enin
2018	6	24	10	55	29.53	12.75	1.29		3.5			135	NDC	Near Kirikiri, Burkina Faso
2018	6	25	8	35	56.74	13.17	0.88		4			1	NDC	Near Kantiana, Burkina Faso
2018	6	25	12	32	54.87	12.04	0.8		4.5			132	NDC	Near Tambiga, Burkina Faso
2018	7	1	8	7	6.67	6.636	-5.44		4.1			141	NDC	Bazai, Cote D'Ivoire
2018	7	1	15	4	34.95	6.663	-4.87		3.5			67	NDC	Assebrako, Cote D'Ivoire
2018	7	2	1	11	24.44	5.795	-5.16		4.5			93	NDC	Ble, Cote D'Ivoire
2018	7	11	18	4	49.72	5.775	-4.75		4.4			95	NDC	Tiassalé, Cote D'Ivoire
2018	7	15	12	38	35.14	5.755	-3.83		4.3			54	NDC	Alepe, Cote D'Ivoire
2018	7	16	12	38	5.7	12.21	1.96		3.9			16	NDC	Tapoa, Cote D'Ivoire
2018	7	20	16	17	25.27	6.033	-4.42		4.1			95	NDC	Agboville, Cote d'Ivoire
2018	7	23	0	14	22.75	5.905	-4.77		4.1			82	NDC	Tiassele, Cote d'Ivoire
2018	7	28	18	23	34.94	5.598	-5.58		4.2			127	NDC	Lakota, Côte d'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2018	8	9	17	1	25.56	7.194	-4.83		4.2			98	NDC	Didievi, Cote d'Ivoire
2018	8	10	9	50	28.71	5.851	-5.22		4.1			122	NDC	Divo, Côte d'Ivoire
2018	8	12	12	29	59.18	4.335	3.06		3.7			159	NDC	Off the coast of Togo, Lome
2018	8	13	15	11	23.28	8.194	-4.71		4.2			101	NDC	Dabakala, Côte d'Ivoire
2018	8	14	11	39	27.35	5.884	-3.72		3.9			19	NDC	Alepe, Côte d'Ivoire
2018	8	18	14	26	45.11	6.089	-5.43		2.7			137	NDC	Divo, Côte d'Ivoire
2018	8	19	5	36	5.6	13.24	-0.38		3.8			14	NDC	Namentenga, Burkina Faso
2018	8	29	1	36	6.44	5.048	-3.81		4.2			55	NDC	Azurette, Cote d'Ivoire
2018	9	1	16	1	10.62	12.5	-2.99		3.4			153	NDC	Nayala, Burkina Faso
2018	9	2	16	21	18.08	6.635	-3.48		3.9			128	NDC	Abengourou, Côte d'Ivoire
2018	9	3	3	27	49.87	6.664	-4.88		2.1			76	NDC	Dimbokro, Côte d'Ivoire
2018	9	4	7	22	15.17	2.882	2.79		4			116	NDC	Off the coast of Togo, Lome
2018	9	6	16	47	53.28	10.39	-2.79		4.4			125	NDC	Upper West Region Wa, Ghana
2018	9	9	21	55	28.84	6.408	-6.17		3.6			171	NDC	Issia, Côte d'Ivoire
2018	9	12	12	23	57.92	6.343	-4.35		4.5			153	NDC	Bongouanou, Côte d'Ivoire
2018	9	13	19	4	29.11	7.698	-5.9		3.7			53	NDC	Zuenoula, Côte d'Ivoire
2018	9	16	8	43	43.53	10.23	2.68		2.1			72	NDC	Bembéréké, Benin
2018	9	18	15	27	5.44	4.146	0.95		3.7			165	NDC	Off the coast of Ghana, Accra
2018	9	21	16	28	5.88	6.633	-5.39		4.2			162	NDC	Yamoussourkro, Côte d'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2018	9	25	1	47	5.35	7.021	-5.79		3.9			31	NDC	Bouafle, Côte d'Ivoire
2018	9	27	3	3	9.29	5.369	-4.79		3.9			86	NDC	Palmeraie, Côte d'Ivoire
2018	10	2	14	59	11.36	5.889	-6.15		4.3			149	NDC	Gagnoa, Côte d'Ivoire
2018	10	3	19	20	54.42	8.003	-7.12		3			55	NDC	Mont Sângbé National Park, Côte d'Ivoire
2018	10	5	23	19	20.73	7.643	-5.85		3.9			40	NDC	Zuenoula, Côte d'Ivoire
2018	10	10	6	9	57.7	12.49	1.86		4.4			81	NDC	Tapoa, Burkina Faso
2018	11	2	10	11	45.7	3.382	-0.07		2.7			52	NDC	Off the coast of Accra, Ghana
2018	11	3	9	0	34.1	6.648	-6.26		3.7			8	NDC	Daloa, Côte d'Ivoire
2018	11	4	4	31	7.29	8.046	-4.56		4.4			41	NDC	Dabakala, Côte d'Ivoire
2018	11	7	8	38	12.96	6.644	-4.9		3.8			57	NDC	Dimbokro, Côte d'Ivoire
2018	11	8	21	23	4.4	5.865	-2.5		4.3			45	NDC	Western Region,Kwaben-Ghana
2018	11	9	14	0	39.54	10.05	2.47		4.4			89	NDC	Sinendé, Benin
2018	11	11	5	17	31.93	12.24	0.64		4.4			158	NDC	Gourma, Burkina Faso
2018	11	12	3	16	22	5.566	-0.34		2.4				GGSA	Near Nananka
2018	11	14	16	6	37.25	4.936	-3.99		4.4			71	NDC	Off the coast of Cote D'ivoire
2018	11	14	16	6	37.25	4.936	-3.99		4.4			71	NDC	Off the coast of Côte d'Ivoire
2018	11	14	20	31	43.23	6.206	-4.96		4.1			41	NDC	Tiassalé, Côte d'Ivoire
2018	11	15	7	39	57.51	5.906	-3.64		4.4			24	NDC	Lagunes District, Côte d'Ivoire
2018	11	18	20	43	47.92	5.464	-4.18		4.4			89	NDC	Abidjan, Côte d'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2018	11	23	1	55	59.56	7.982	-5.32		3.9			49	NDC	Bouaké, Côte d'Ivoire
2018	11	24	8	18	43.91	6.935	-5.74		4.2			36	NDC	Bouafle, Côte d'Ivoire
2018	11	24	14	21	37.85	7.183	-6.19		4.3			10	NDC	Daloa, Côte d'Ivoire
2018	11	29	4	39	1.71	11.77	1.56		4.3			115	NDC	Tapoa, Burkina Faso
2018	11	29	23	12	14.92	6.306	-5.62		4			146	NDC	Oume, Côte d'Ivoire
2018	11	29	23	15	58.29	4.849	-5.77		4.2			122	NDC	Off the coast of Côte d'Ivoire
2018	11	30	18	57	42.76	8.042	-4.96		4.4			99	NDC	Near Bouake, Cote d'Ivoire
2018	12	5	4	15	56.77	4.623	-3.59		4.4			80	NDC	Near Abidjan, Cote d'Ivoire
2018	12	9	7	50	11.55	7.247	-1.31		4.2			140	NDC	Kumasi, Ghana
2018	12	9	12	20	54.27	5.655	-5.39		3.9			125	NDC	Lakota, Cote d'Ivoire
2018	12	9	7	49	52	5.566	-0.34		3.3				GGSA	Near Hevite
2018	12	9	19	44	3.01	6.399	-2.48		3.9			170	NDC	Atwima Mponua, Ghana
2018	12	13	3	44	54.96	3.088	-2.06		3.9			131	NDC	Takoradi, Ghana
2018	12	13	5	1	58.42	12.95	-0.98		4.1			160	NDC	Tougouri, Burkina Faso
2018	12	13	11	10	58.51	11.68	1.95		3.3			92	NDC	Partiaga, Burkina Faso
2018	12	13	12	57	5.69	6.301	-1.09		4.2			166	NDC	New Abirem, Ghana
2018	12	17	18	40	5.59	6.748	-4.07		4.4			152	NDC	Kotobi, Cote d'Ivoire
2018	12	18	5	22	15.67	6.095	-6.1		3.8			10	NDC	Soubre, Cote d'Ivoire

Source: Field Work (2012 - 2018)

Yr	M	D	H	Min	Sec	Lat	Lon	Dp	Mw	Io	RS	Az	Ref	Location
2018	12	18	18	50	8.86	6.162	-4.58		4.2			99	NDC	Agboville, Cote d'Ivoire
2018	12	21	10	33	38.07	5.157	-3.67		3.8			50	NDC	Azuretti, Cote d'Ivoire
2018	12	24	9	35	47.17	6.112	-6.03		4.4			158	NDC	Bogrenyoa, Cote d'Ivoire
2018	12	29	11	29	24.38	9.693	-6.07		2.8			126	NDC	N'Ganon, Cote d'Ivoire
2018	12	29	20	8	52.37	6.119	-3.53		4.2			40	NDC	Abradinou, Cote d'Ivoire
2018	12	30	1	15	4.84	8.322	-4.73		3.9			95	NDC	Dambakala, Cote d'Ivoire
2018	12	30	3	30	39.92	5.84	-6.77		4			8	NDC	Soubre, Cote d'Ivoire

Source: Field Work (2012 - 2018)

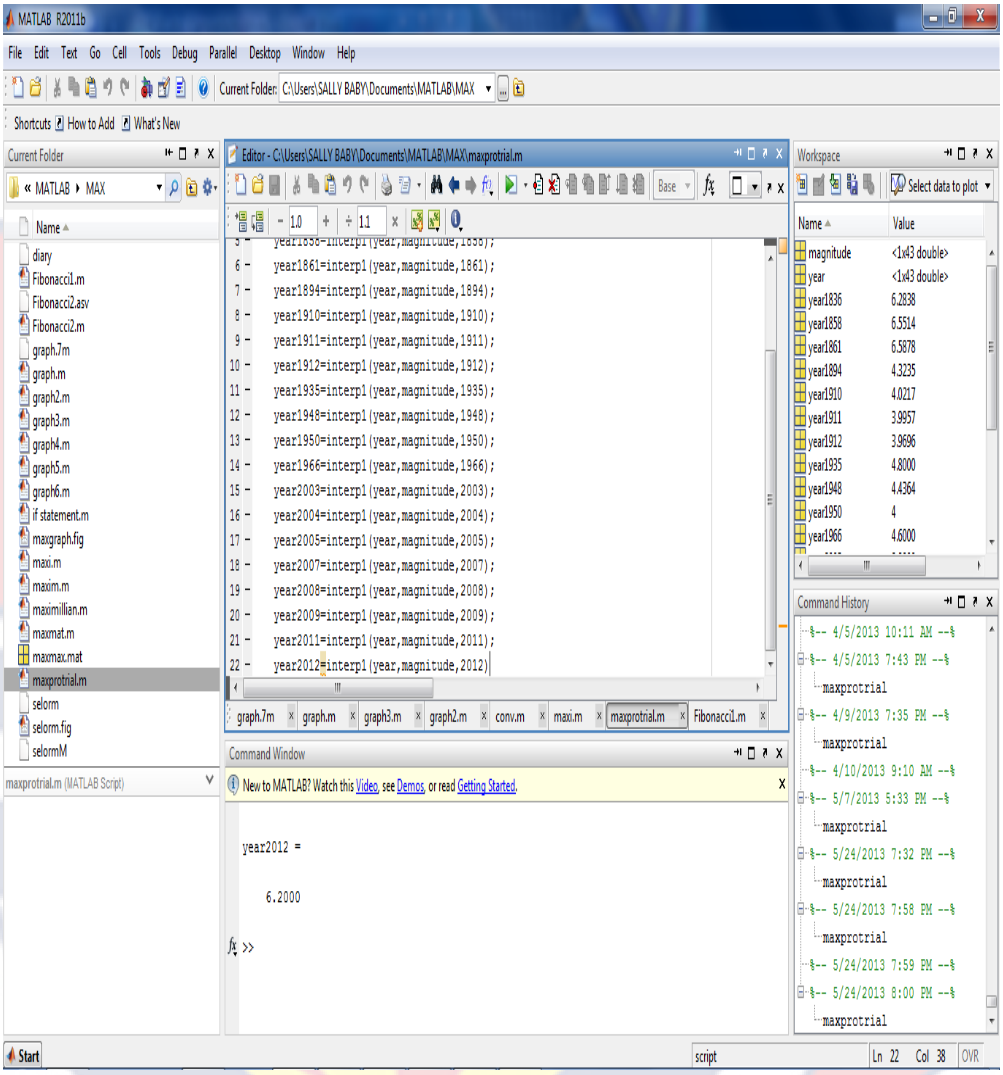
APPENDIX B

MATLAB INTERPOLATION

(α) Command and Results

```
year=[1636 1788 1862 1870 1871 1872 1879 1883 1889 1906 1907
1930 1933 1939 1950 1964 1969 1973 1974 1977 1978 1979 1987
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
2000 2001 2002 2003 2009 2010 2011 2012];
magnitude=[5.8 5.7 6.6 4.6 4.7 5.0 5.8 4.7 4.0 5.1 4.1 3.5 4.0 6.4 4.0
4.4 4.9 2.4 3.6 2.8 3.7 3.4 2.7 3.3 2.1 3.3 3.7 2.0 4.2 2.8 3.8 3.4 4.6 2.3
2.6 3.1 2.2 3.0 2.9 4.4 4.6 4.6 6.2 ];
year1836=interp1(year,magnitude,1836);
year1858=interp1(year,magnitude,1858);

year1861=interp1(year,magnitude,1861);

year1894=interp1(year,magnitude,1894);

year1910=interp1(year,magnitude,1910);

year1911=interp1(year,magnitude,1911);

year1912=interp1(year,magnitude,1912);

year1935=interp1(year,magnitude,1935);

year1948=interp1(year,magnitude,1948);

year1950=interp1(year,magnitude,1950);

year1966=interp1(year,magnitude,1966);

year2003=interp1(year,magnitude,2003);

year2004=interp1(year,magnitude,2004);

year2005=interp1(year,magnitude,2005);

year2007=interp1(year,magnitude,2007);

year2008=interp1(year,magnitude,2008);

year2009=interp1(year,magnitude,2009);

year2011=interp1(year,magnitude,2011);

year2012=interp1(year,magnitude,2012)
```

(β) Matlab Window



```
year1861=interp1(year,magnitude,1861);
year1894=interp1(year,magnitude,1894);
year1910=interp1(year,magnitude,1910);
year1911=interp1(year,magnitude,1911);
year1912=interp1(year,magnitude,1912);
year1935=interp1(year,magnitude,1935);
year1948=interp1(year,magnitude,1948);
year1950=interp1(year,magnitude,1950);
year1966=interp1(year,magnitude,1966);
year2003=interp1(year,magnitude,2003);
year2004=interp1(year,magnitude,2004);
year2005=interp1(year,magnitude,2005);
year2007=interp1(year,magnitude,2007);
year2008=interp1(year,magnitude,2008);
year2009=interp1(year,magnitude,2009);
year2011=interp1(year,magnitude,2011);
year2012=interp1(year,magnitude,2012)
```

```
year2012 =

    6.2000

fx >>
```

Name	Value
magnitude	<1x43 double>
year	<1x43 double>
year1836	6.2838
year1858	6.5514
year1861	6.5878
year1894	4.3235
year1910	4.0217
year1911	3.9957
year1912	3.9696
year1935	4.8000
year1948	4.4364
year1950	4
year1966	4.6000

```
%-- 4/5/2013 10:11 AM --%
%-- 4/5/2013 7:43 PM --%
   maxprotrial
%-- 4/9/2013 7:35 PM --%
   maxprotrial
%-- 4/10/2013 9:10 AM --%
%-- 5/7/2013 5:33 PM --%
   maxprotrial
%-- 5/24/2013 7:32 PM --%
   maxprotrial
%-- 5/24/2013 7:58 PM --%
   maxprotrial
%-- 5/24/2013 7:59 PM --%
%-- 5/24/2013 8:00 PM --%
   maxprotrial
```

APPENDIX C

RADON CONCENTRATIONS

1. Highest Concentration per Year

YEAR	METHOD	HIGHEST CONC./Bqm^{-3} SOIL	WATER	LOCATION
1989	SSNTD	91.80		Dome
1990	SSNTD	9.40		Kwabenya
1991	SSNTD	1226.00		Ankaful
1993	SSNTD	144.4.00		Prestea
1994	SSNTD	16200.00		Prestea
1999	SSNTD	27000.00		Dunkonah
2001	Rolles	71.00		KNUST
2007	RDU-200	5671.70		Dormaa Ahenkro
2008	SSNTD	25920.00		Accra
2009	SSNTD	132.70		Kasena Nankana
2010	SSNTD	466.90		Dome
2011	SSNTD	1720.00		GAEC
2012	SSNTD	37390.00	723.70	GAEC, Kasena Nankana
2014		753.51		Keta
2015	SSNTD	2550.00		Dome Kwabenya
2016	SSNTD, SSNTD	1193.00	0.17	Accra Central
2018	SSNTD, EPERMS, SSNTD	36321.55	8000 51518.01	GAMA

Source: Field Work (2012 - 2018)

2. Summary of Regional Average Radon Concentrations

	AVERAGE RADON CONCENTRATION (Bqm^{-3})		
REGION	RADON IN SOIL	RADON IN WATER	INDOOR RADON
Ashanti	4653.52	-	114.33
Brong Ahafo	4235.85	-	-
Central	1192.00	-	276.00
Eastern	-	-	49.78
Greater Accra	9048.35	0.17	317.95
Northern	2711.89	-	-
Upper East	132.70	723.70	130.03
Upper West	-	-	35.75
Volta	778.15	-	34.90
Western	6981.47	-	-
National Average	**3716.74**	**361.93**	**136.96**

Source: Field Work (2012 - 2018)

APPENDIX D

KOBO AND SPSS (DID YOU FEEL IT?) INVESTIGATION

i. Seismic Research Questionnaire (Coding)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	2	1	2	3	1	2	2	2
1	2	2	3	4	5	6	5	3
1	2	2	4	3	5	6	5	3
1	2	2	2	3	5	3	2	1
1	2	2	2	3	6	5	1	2
1	2	2	2	3	4	2	2	2
1	2	2	3	3	5	6	5	3
1	2	2	3	1	1	1	1	1
1	2	2	2	4	5	5	5	2
1	2	1	2	3	1	2	2	2
1	2	2	2	4	5	3	2	2
1	1	1	1	1	1	1	1	1

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	2	5	2	5	5	3	5	1
1	2	2	1	1	4	6	2	1
1	2	3	2	4	3	6	6	3
1	2	2	1	1	3	1	2	2
1	2	3	2	4	5	3	6	3
1	2	3	2	4	3	3	1	1
1	1	1	1	1	1	1	1	1
1	1	1	1	3	1	3	2	2
1	2	2	1	1	3	1	2	2
1	2	2	3	3	5	3	2	2
1	1	3	4	3	6	3	3	3
1	2	2	3	3	5	3	3	3

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	2	3	4	5	5	5	5	2
1	2	2	2	5	5	5	3	2
1	2	2	3	4	5	5	2	1
1	1	3	2	5	5	6	2	3
1	2	3	2	3	4	3	2	1
1	2	2	4	5	3	6	5	2
1	1	2	2	5	4	5	5	2
1	2	2	2	5	5	3	2	2
1	2	2	2	5	5	6	3	2
1	2	2	2	5	4	5	2	2
1	2	2	2	2		3	5	2
1	2	3	4	3	4	4	2	1

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	1	2	2	3	2	2	2	2
1	2	2	3	3	1	1	1	1
2	2	2	3	4	2	2	2	2
1	2	2	4	3	3	3	2	1
1	2	2	2	3	5	6	4	3
1	1	2	2	4	5	7	3	3
1	2	2	3	3	5	6	3	2
1	2	2	2	2	4	3	2	2
1	1	2	1	3	2	1	2	1
1	2	1	1	2	2	1	1	1
1	2	2	1	2	3	4	1	1
1	2	1	1	2	1	1	1	1

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	2	2	2	2	1	3	1	2
1	2	3	1	2	4	5	2	1
1	2	2	3	4	4	3	2	1
1	1	4	2	1	3	1	1	1
1	2	2	2	2	1	1	2	1
1	2	1	1	2	3	1	2	2
1	2	1	2	5	3	4	2	2
1	2	1	1	2	3	1	1	3
1	2	1	2	1	1	2	1	1
1	2	1	1	2	2	1	1	1
1	2	1	2	2	2	1	1	1
1	2	1	1	2	4	5	2	2

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	1	3	2	5	5	5	1	2
1	2	1	1	1	2	2	2	2
1	2	1	1	1	5	1	1	1
1	1	3	2	2	4	3	2	1
1	2	1	1	1	2	1	1	1
1	2	2	1	1	2	1	2	1
1	1	3	1	4	4	3	2	2
1	2	1	2	2	3	4	3	3
1	2	2	4	2	2	1	3	2
1	2	1	1	2	4	2	1	2
1	1	3	2	4	4	3	2	2
1	2	1	1	2	1	2	1	3

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	2	1	2	2	2	1	1	2
1	1	3	2	4	4	3	2	2
1	2	1	2	1	1	2	1	2
1	2	3	1	2	5	1	2	2
1	1	3	2	4	5	2	2	2
1	1	1	1	1	6	2	2	2
1	1	2	1	2	5	2	1	3
1	1	3	2	4	5	3	2	2
1	1	1	1	1	2	2	1	2
1	2	1	1	5	1	1	3	2
1	1	3	2	4	5	3	2	2
1	1	3	2	4	5	3	2	2

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	2	2	2	3	2	1	2	2
1	2	1	3	2	1	1	3	1
1	1	3	2	4	5	3	2	2
1	1	3	2	4	3	3	2	2
1	1	3	2	4	3	3	2	2
1	1	3	2	4	4	3	2	2
1	2	2	1	1	2	2	2	2
1	1	3	2	4	3	3	2	2
1	2	4	2	2	2	2	2	1
1	1	3	2	4	3	3	2	2
1	1	3	2	4	4	3	2	2
1	1	3	2	4	4	3	2	2

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	1	3	2	4	4	3	2	2
1	2	1	1	2	2	2	1	2
1	2	2	1	3	2	2	2	2
1	1	3	2	4	4	3	2	2
1	1	3	2	4	4	3	2	2
1	2	1	1	1	2	2	2	2
1	1	3	2	4	4	3	2	2
1	2	1	3	1	2	2	2	2
1	1	3	2	4	4	3	2	2
1	2	1	2	4	2	2	3	1
1	1	3	2	4	4	3	2	2
1	2	4	1	2	2	2	1	2

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	1	3	2	4	4	3	2	2
1	1	3	2	4	5	3	2	2
1	1	3	2	4	4	3	2	2
1	2	4	2	3	3	4	2	2
1	1	1	2	2	4	2	1	2
1	1	3	2	4	4	3	2	2
1	2	1	1	2	1	1	2	1
1	2	2	3	3	3	3	2	2
1	1	2	1	2	2	5	4	2
1	1	3	2	1	1	2	2	3
1	1	1	2	2	3	1	2	2
1	2	2	2	5	1	1	2	1

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	1	1	4	2	3	5	5	1
1	2	3	2	1	5	5	3	2
1	2	1	1	2	2	1	5	2
1	1	3	1	1	2	2	2	2
1	1	1	2	5	4	5	2	3
1	2	2	3	3	5	3	3	3
1	2	3	4	5	5	5	5	2
1	2	2	2	5	5	5	3	2
1	2	2	3	4	5	5	2	1
1	1	3	2	5	5	6	2	3
1	2	2	2	3	4	3		1
1	2	2	4	5	3	6	5	2

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	1	2	2	5	4	5	5	2
1	2	2	2	5	5	3	2	2
1	2	2	2	5	5	6	3	2
1	2	2	2	5	4	5	2	2
1	2	3	4	3	4	4	2	1
1	1	2	2	3	2	2	2	2
1	2	2	3	3	1	1	1	1
1	2	2	3	4	2	2	2	2
1	2	2	4	3	3	3	2	1
1	2	2	2	3	5	6	4	3
1	1	2	2	4	5	7	3	3
1	2	2	3	3	5	6	3	2

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	2	2	2	2	4	3	2	2
1	1	2	1	3	2	1	2	1
1	2	1	1	2	2	1	1	1
1	2	2	1	2	3	4	1	1
1	2	1	1	2	1	1	1	1
1	2	2	2	2	1	3	1	2
1	2	3	1	2	4	5	2	1
1	2	2	3	4	4	3	2	1
1	1	4	2	1	3	1	1	1
1	2	2	2	2	1	1	2	1
1	2	1	1	2	3	1	2	2
1	2	1	2	5	3	4	2	2

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	2	1	1	2	3	1	1	3
1	2	1	2	1	1	2	1	1
1	2	1	1	2	2	1	1	1
1	2	1	2	2	2	1	1	1
1	2	1	1	2	4	5	2	2
1	2	1	1	2	5	1	2	3
1	1	3	2	5	5	5	1	2
1	2	1	1	1	2	2	2	2
1	2	1	1	1	5	1	1	1
1	1	3	2	2	4	3	2	1
1	2	1	1	1	2	1	1	1
1	2	2	1	1	2	1	2	1

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	1	3	1	4	4	3	2	2
1	2	1	2	2	3	4	3	3
1	2	2	4	2	2	1	3	2
1	2	1	1	2	4	2	1	2
1	1	3	2	4	4	3	2	2
1	2	1	1	2	1	2	1	3
1	2	1	2	2	2	1	1	2
1	1	3	2	4	4	3	2	2
1	2	1	2	1	1	2	1	2
1	2	3	1	2	5	1	2	2
1	1	3	2	4	5	2	2	2
1	1	1	1	1	6	2	2	2

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	1	2	1	2	5	2	1	3
1	1	3	2	4	5	3	2	2
1	1	1	1	1	2	2	1	2
1	2	1	1	5	1	1	3	2
1	1	3	2	4	5	3	2	2
1	1	3	2	4	5	3	2	2
1	2	2	2	3	2	1	2	2
1	2	1	3	2	1	1	3	1
1	1	3	2	4	5	3	2	2
1	1	3	2	4	3	3	2	2
1	1	3	2	4	3	3	2	2
1	1	3	2	4	4	3	2	2

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	2	2	1	1	2	2	2	2
1	1	3	2	4	3	3	2	2
1	2	4	2	2	2	2	2	1
1	1	3	2	4	3	3	2	2
1	1	3	2	4	4	3	2	2
1	1	3	2	4	4	3	2	2
1	1	3	2	4	4	3	2	2
1	2	1	1	2	2	2	1	2
1	2	2	1	3	2	2	2	2
1	1	3	2	4	4	3	2	2
1	1	3	2	4	4	3	2	2
1	2	1	1	1	2	2	2	2

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	1	3	2	4	4	3	2	2
1	2	1	3	1	2	2	2	2
1	1	3	2	4	4	3	2	2
1	2	1	2	4	2	2	3	1
1	1	3	2	4	4	3	2	2
1	2	4	1	2	2	2	1	2
1	1	3	2	4	4	3	2	2
1	1	3	2	4	5	3	2	2
1	1	3	2	4	4	3	2	2
1	2	4	2	3	3	4	2	2
1	1	1	2	2	4	2	1	2
1	1	3	2	4	4	3	2	2

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	2	1	1	2	1	1	2	1
1	2	2	3	3	3	3	2	2
1	1	2	1	2	2	5	4	2
1	1	3	2	1	1	2	2	3
1	1	1	2	2	3	1	2	2
1	2	2	2	5	1	1	2	1
1	1	3	2	3	2	1	2	1
1	1	1	4	2	3	5	5	1
1	2	3	2	1	5	5	3	2
1	2	2	2	3	5	3	2	1
1	2	2	2	3	6	5	1	2
1	2	2	2	3	4	2	2	2

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	2	2	3	3	5	6	5	3
1	2	2	3	1	1	1	1	1
1	2	2	2	4	5	5	5	2
1	2	1	2	3	1	2	2	2
1	2	2	2	4	5	3	2	2
1	2	2	2	2	4	3	2	2
1	1	2	1	3	2	1	2	1
1	2	1	1	2	2	1	1	1
1	2	2	1	2	3	4	1	1
1	2	1	1	2	1	1	1	1
1	2	2	2	2	1	3	1	2
1	2	3	1	2	4	5	2	1

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	2	2	3	4	4	3	2	1
1	1	4	2	1	3	1	1	1
1	2	2	2	2	1	1	2	1
1	2	1	1	2	3	1	2	2
1	2	1	2	5	3	4	2	2
1	2	1	1	2	3	1	1	3
1	2	1	2	1	1	2	1	1
1	2	1	1	2	2	1	1	1
1	2	1	2	2	2	1	1	1
1	2	1	1	2	4	5	2	2
1	2	1	1	2	5	1	2	3
1	1	3	2	5	5	5	1	2

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	2	1	1	1	2	2	2	2
1	2	1	1	1	5	1	1	1
1	1	3	2	2	4	3	2	1
1	2	1	1	1	2	1	1	1
1	2	2	1	1	2	1	2	1
1	1	3	1	4	4	3	2	2
1	2	1	2	2	3	4	3	3
1	2	2	4	2	2	1	3	2
1	2	1	1	2	4	2	1	2
1	1	3	2	4	4	3	2	2
1	2	1	1	2	1	2	1	3
1	2	1	2	2	2	1	1	2

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	1	3	2	4	4	3	2	2
1	2	1	2	1	1	2	1	2
1	2	3	1	2	5	1	2	2
1	1	3	2	4	5	2	2	2
1	1	1	1	1	6	2	2	2
1	1	2	1	2	5	2	1	3
1	1	3	2	4	5	3	2	2
1	1	1	1	1	2	2	1	2
1	2	1	1	5	1	1	3	2
1	1	3	2	4	5	3	2	2
1	1	3	2	4	5	3	2	2
1	2	2	2	3	2	1	2	2

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	2	1	3	2	1	1	3	1
1	1	3	2	4	5	3	2	2
1	1	3	2	4	3	3	2	2
1	1	3	2	4	3	3	2	2
1	1	3	2	4	4	3	2	2
1	2	2	1	1	2	2	2	2
1	1	3	2	4	3	3	2	2
1	2	4	2	2	2	2	2	1
1	1	3	2	4	3	3	2	2
1	1	3	2	4	4	3	2	2
1	1	3	2	4	4	3	2	2
1	1	3	2	4	4	3	2	2

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	2	1	1	2	2	2	1	2
1	2	2	1	3	2	2	2	2
1	1	3	2	4	4	3	2	2
1	1	3	2	4	4	3	2	2
1	2	1	1	1	2	2	2	2
1	1	3	2	4	4	3	2	2
1	2	1	3	1	2	2	2	2
1	2	1	1	2	1	1	1	1
2	2	2	2	2	1	3	1	2
1	2	3	1	2	4	5	2	1
1	2	2	3	4	4	3	2	1
1	1	4	2	1	3	1	1	1

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	What was your situation during the earthquake?	Were you asleep?	Did 6s nearby feel it?	How would you describe the shaking?	How did you react?	How did you respond?	Was it difficult to stand and/or walk?
1	2	2	2	2	1	1	2	1
1	2	1	1	2	3	1	2	2
2	2	1	2	2	3	4	2	2
1	2	1	1	2	3	1	1	3
1	2	1	2	1	1	2	1	1
1	2	1	1	2	2	1	1	1
1	2	1	2	2	2	1	1	1
1	2	1	1	2	4	1	2	2

Source: Field Work (2018)

ii. Seismic Research Questionnaire (Some Key Responses)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kasoa	Not specified	No	Some felt it, most did not	Not specified
Yes	Night	Kasoa iron city	Inside a building	Slept through it	Most felt it	Strong
Yes	Night	kasoa	Inside a building	Woke up	Some felt it, most did not	Strong
Yes	Night	kasoa-Amasaman	Inside a building	No	Some felt it, most did not	Moderate
Yes	Night	kasoa	Inside a building	No	Some felt it, most did not	Violent
Yes	Night	Kasoa	Inside a building	No	Some felt it, most did not	Mild
Yes	Night	Amanfro	Inside a building	Slept through it	Some felt it, most did not	Moderate

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kasoa	Inside a building	Slept through it	Not specified	Not specified
Yes	Night	Kasoa	Inside a building	No	Most felt it	Moderate
Yes	Night	Kasoa	Not specified	No	Some felt it, most did not	Not specified
Yes	Night	kasoa	Inside a building	No	Most felt it	Moderate
Yes	Day	kasoa	Not specified	Not specified	Not specified	Not specified
Yes	Night	kasoa	Other	No	Everyone/almost everyone felt it	Moderate
Yes	Night	Kasoa	Inside a building	Not specified	Not specified	Mild

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	kasoa	Outside a building	No	Most felt it	Weak
Yes	Day	Kasoa	Not specified	Not specified	Not specified	Not specified
Yes	Day	Kasoa	Not specified	Not specified	Some felt it, most did not	Not specified
Yes	Night	Kasoa	Inside a building	Not specified	Not specified	weak
Yes	Night	At kasoa	Inside a building	Slept through it	Some felt it, most did not	Moderate
Yes	Day	Asikuma	Outside a building	Woke up	Some felt it, most did not	Violent
Yes	Night	Kasoa	Inside a building	Slept through it	Some felt it, most did not	Moderate

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	kasoa	Outside a building	Woke up	Everyone/almost everyone felt it	Moderate
Yes	Night	kasoa	Inside a building	No	Everyone/almost everyone felt it	Moderate
Yes	Night	kasoa	Inside a building	Slept through it	Most felt it	Moderate
Yes	Day	kasoa	Outside a building	No	Everyone/almost everyone felt it	Strong
Yes	Night	Kasoa	Outside a building	No	Some felt it, most did not	Mild
Yes	Night	Donkunah	Inside a building	Woke up	Everyone/almost everyone felt it	Weak
Yes	Day	kasoa	Inside a building	No	Everyone/almost everyone felt it	Mild

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	kasoa	Inside a building	No	Everyone/almost everyone felt it	Moderate
Yes	Night	Donkunah	Inside a building	No	Everyone/almost everyone felt it	Moderate
Yes	Night	Donkunah	Inside a building	No	Everyone/almost everyone felt it	Mild
Yes	Night	Donkunah	Inside a building	no	No others felt it	
Yes	Night	At kasoa	Outside a building	Woke up	Some felt it, most did not	Mild
Yes	Day	kasoa	Inside a building	No	Some felt it, most did not	Not felt
Yes	Night	kasoa	Inside a building	Slept through it	Some felt it, most did not	Not specified

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	kasoa	Inside a building	Slept through it	Most felt it	Not felt
Yes	Night	kasoa	Inside a building	Woke up	Some felt it, most did not	Weak
Yes	Night	Kasoa	Inside a building	No	Some felt it, most did not	Moderate
Yes	Day	Kasoa	Inside a building	No	Most felt it	Strong
Yes	Night	Donkunah	Inside a building	Slept through it	Some felt it, most did not	Moderate
Yes	Night	Kasoa	Inside a building	No	No others felt it	Mild
Yes	Day	Donkunah	Inside a building	Not specified	Some felt it, most did not	Not felt

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Not felt
Yes	Night	Donkunah	Inside a building	Not specified	No others felt it	Weak
Yes	Night	Donkunah	Not specified	Not specified	No others felt it	Not specified
Yes	Night	Donkunah	Inside a building	No	No others felt it	Not specified
Yes	Night	Kasoa	Outside a building	Not specified	No others felt it	Mild
Yes	Night	Kasoa	Inside a building	Slept through it	Most felt it	Mild
Yes	Day	Weija	In a stopped vehicle	No	Not specified	Weak

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kasoa	Inside a building	No	No others felt it	Not specified
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Weak
Yes	Night	Weija	Not specified	No	Everyone/almost everyone felt it	Weak
Yes	Night	Weija	Not specified	Not specified	No others felt it	Weak
Yes	Night	Weija	Not specified	No	Not specified	Not specified
Yes	Night	Weija	Not specified	Not specified	No others felt it	Not felt
Yes	Night		Not specified	No	No others felt it	Not felt

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Weija	Not specified	Not specified	No others felt it	Mild
Yes	Night	Weija	Not specified	Not specified	No others felt it	Moderate
Yes	Day	Kasoa	Outside a building	No	Everyone/almost everyone felt it	Strong
Yes	Night	Kasoa	Not specified	Not specified	Not specified	Not felt
Yes	Night	Kasoa	Not specified	Not specified	Not specified	Moderate
Yes	Day	Kasoa	Outside a building	No	No others felt it	Mild
Yes	Night	Kasoa	Not specified	Not specified	Not specified	Not felt

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kasoa	Inside a building	Not specified	Not specified	Not felt
Yes	Day	Kasoa	Outside a building	Not specified	Most felt it	Mild
Yes	Night	Weija	Not specified	No	No others felt it	Weak
Yes	Night	Kasoa	Inside a building	Woke up	No others felt it	Not felt
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Mild
Yes	Day	Weija	Outside a building	No	Most felt it	Mild
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Not specified

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kasoa	Not specified	No	No others felt it	Not felt
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Night	Kasoa	Not specified	No	Not specified	Not specified
Yes	Night	Kasoa Weija	Outside a building	Not specified	No others felt it	Moderate
Yes	Day	Weija	Outside a building	No	Most felt it	Moderate
Yes	Day	Weija	Not specified	Not specified	Not specified	Violent
Yes	Day		Inside a building	Not specified	No others felt it	Strong

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Day	Weija	Outside a building	No	Most felt it	Moderate
Yes	Day	Weija	Not specified	Not specified	Not specified	Not felt
Yes	Night	Kasoa	Not specified	Not specified	Everyone/almost everyone felt it	Not specified
Yes	Day	Kasoa	Outside a building	No	Most felt it	Moderate
Yes	Day	Kasoa	Outside a building	No	Most felt it	Moderate
Yes	Night	Kasoa	Inside a building	No	Some felt it, most did not	Not felt
Yes	Night	Donkunah	Not specified	Slept through it	No others felt it	Not specified

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Day	Kasoa	Outside a building	No	Most felt it	Moderate
Yes	Day	Kasoa	Outside a building	No	Most felt it	Weak
Yes	Day	Donkunah	Outside a building	No	Most felt it	Weak
Yes	Day	Donkunah	Outside a building	No	Most felt it	Mild
Yes	Night	Kasoa	Inside a building	Not specified	Not specified	Not felt
Yes	Day	Kasoa	Outside a building	No	Most felt it	Weak
Yes	Night	Donkunah	In a stopped vehicle	No	No others felt it	Not felt

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Day	Kasoa	Outside a building	No	Most felt it	Weak
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Not felt
Yes	Night	Kasoa	Inside a building	Not specified	Some felt it, most did not	Not felt
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Night	Weija	Not specified	Not specified	Not specified	Not felt
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Night	Kasoa	Not specified	Slept through it	Not specified	Not felt
Yes	Day	Weija	Outside a building	No	Most felt it	Mild
Yes	Night	Kasoa	Not specified	No	Most felt it	Not felt
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kasoa	In a stopped vehicle	Not specified	No others felt it	Not felt
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Day	Kasoa	Outside a building	No	Most felt it	Moderate
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Night	Weija	In a stopped vehicle	No	Some felt it, most did not	Weak
Yes	Day	Kasoa	Not specified	No	No others felt it	Mild
Yes	Day	Weija	Outside a building	No	Most felt it	Mild

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Not specified
Yes	Night	Kasoa	Inside a building	Slept through it	Some felt it, most did not	Weak
Yes	Day	Kasoa	Inside a building	Not specified	No others felt it	Not felt
Yes	Day	Weija	Outside a building	No	Not specified	Not specified
Yes	Day	Kasoa	Not specified	No	No others felt it	Weak
Yes	Night	Kasoa	Inside a building	No	Everyone/almost everyone felt it	Not specified
Yes	Day	Kasoa	Outside a building	No	Some felt it, most did not	Not felt

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Day	Kasoa	Not specified	Woke up	No others felt it	Weak
Yes	Night	Kasoa	Outside a building	No	Not specified	Moderate
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Not felt
Yes	Day	Kasoa	Outside a building	Not specified	Not specified	Not felt
Yes	Day	Accra	Not specified	No	Everyone/almost everyone felt it	Mild
Yes	Night	Kasoa	Inside a building	Slept through it	Some felt it, most did not	Moderate
Yes	Night	kasoa	Outside a building	Woke up	Everyone/almost everyone felt it	Moderate

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Accra	Inside a building	No	Everyone/almost everyone felt it	Moderate
Yes	Night	kasoa	Inside a building	Slept through it	Most felt it	Moderate
Yes	Day	kasoa	Outside a building	No	Everyone/almost everyone felt it	Strong
Yes	Night	Accra	Inside a building	No	Some felt it, most did not	Mild
Yes	Night	Kasoa	Inside a building	Woke up	Everyone/almost everyone felt it	Weak
Yes	Day	Kasoa	Inside a building	No	Everyone/almost everyone felt it	Mild
Yes	Night	Accra	Inside a building	No	Everyone/almost everyone felt it	Moderate

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Accra	Inside a building	No	Some felt it, most did not	Moderate
Yes	Day	Accra	Inside a building	No	Most felt it	Strong
Yes	Night	Weija	Inside a building	Slept through it	Some felt it, most did not	Moderate
Yes	Night	Kasoa	Inside a building	No	No others felt it	Mild
Yes	Day	Kasoa	Inside a building	Not specified	Some felt it, most did not	Not felt
Yes	Night	Weija	Not specified	Not specified	No others felt it	Not felt
Yes	Night	Weija	Inside a building	Not specified	No others felt it	Weak

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Weija	Not specified	Not specified	No others felt it	Not specified
Yes	Night	Weija	Inside a building	No	No others felt it	Not specified
Yes	Night	Kasoa	Outside a building	Not specified	No others felt it	Mild
Yes	Night	Kasoa	Inside a building	Slept through it	Most felt it	Mild
Yes	Day	Kasoa	In a stopped vehicle	No	Not specified	Weak
Yes	Night	Kasoa	Inside a building	No	No others felt it	Not specified
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Weak

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kasoa	Not specified	No	Everyone/almost everyone felt it	Weak
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Weak
Yes	Night	Kasoa	Not specified	No	Not specified	Not specified
Yes	Night	Accra	Not specified	Not specified	No others felt it	Not felt
Yes	Night	Kasoa	Not specified	No	No others felt it	Not felt
Yes	Night	Accra	Not specified	Not specified	No others felt it	Mild
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Moderate

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Day	Kasoa	Outside a building	No	Everyone/almost everyone felt it	Strong
Yes	Night	Kasoa	Not specified	Not specified	Not specified	Not felt
Yes	Night	Accra	Not specified	Not specified	Not specified	Moderate
Yes	Day	Accra	Outside a building	No	No others felt it	Mild
Yes	Night	Accra	Not specified	Not specified	Not specified	Not felt
Yes	Night	Kasoa	Inside a building	Not specified	Not specified	Not felt
Yes	Day	Accra	Outside a building	Not specified	Most felt it	Mild

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kasoa	Not specified	No	No others felt it	Weak
Yes	Night	Kasoa	Inside a building	Woke up	No others felt it	Not felt
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Mild
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Not specified
Yes	Night	Accra	Not specified	No	No others felt it	Not felt
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kasoa	Not specified	No	Not specified	Not specified
Yes	Night	Accra	Outside a building	Not specified	No others felt it	Moderate
Yes	Day	Kasoa	Outside a building	No	Most felt it	Moderate
Yes	Day	Kasoa	Not specified	Not specified	Not specified	Violent
Yes	Day	Accra	Inside a building	Not specified	No others felt it	Strong
Yes	Day	Accra	Outside a building	No	Most felt it	Moderate
Yes	Day	Accra	Not specified	Not specified	Not specified	Not felt

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kasoa	Not specified	Not specified	Everyone/almost everyone felt it	Not specified
Yes	Day	Kasoa	Outside a building	No	Most felt it	Moderate
Yes	Day	Weija	Outside a building	No	Most felt it	Moderate
Yes	Night	Kasoa	Inside a building	No	Some felt it, most did not	Not felt
Yes	Night	Weija	Not specified	Slept through it	No others felt it	Not specified
Yes	Day	Kasoa	Outside a building	No	Most felt it	Moderate
Yes	Day	Weija	Outside a building	No	Most felt it	Weak

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Day	Kasoa	Outside a building	No	Most felt it	Weak
Yes	Day	Weija	Outside a building	No	Most felt it	Mild
Yes	Night	Kasoa	Inside a building	Not specified	Not specified	Not felt
Yes	Day	Kasoa	Outside a building	No	Most felt it	Weak
Yes	Night	Kasoa	In a stopped vehicle	No	No others felt it	Not felt
Yes	Day	Kasoa	Outside a building	No	Most felt it	Weak
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Not felt
Yes	Night	Kasoa	Inside a building	Not specified	Some felt it, most did not	Not felt
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Day	Accra	Outside a building	No	Most felt it	Mild
Yes	Night	Accra	Not specified	Not specified	Not specified	Not felt

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Day	Accra	Outside a building	No	Most felt it	Mild
Yes	Night	Kasoa	Not specified	Slept through it	Not specified	Not felt
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Night	Kasoa	Not specified	No	Most felt it	Not felt
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Night	Kasoa	In a stopped vehicle	Not specified	No others felt it	Not felt
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Day	Kasoa	Outside a building	No	Most felt it	Moderate
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Not specified
Yes	Night	Kasoa	Inside a building	Slept through it	Some felt it, most did not	Weak

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Day	Kasoa	Inside a building	Not specified	No others felt it	Not felt
Yes	Day	Kasoa	Outside a building	No	Not specified	Not specified
Yes	Day	Kasoa	Not specified	No	No others felt it	Weak
Yes	Night	Kasoa	Inside a building	No	Everyone/almost everyone felt it	Not specified
Yes	Day	Kasoa	Outside a building	No	Some felt it, most did not	Not felt
Yes	Day	Kasoa	Not specified	Woke up	No others felt it	Weak
Yes	Night	Kasoa	Outside a building	No	Not specified	Moderate

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	kasoa-Amasaman	Inside a building	No	Some felt it, most did not	Moderate
Yes	Night	Kasoa	Inside a building	No	Some felt it, most did not	Violent
Yes	Night	Kasoa	Inside a building	No	Some felt it, most did not	Mild
Yes	Night	Kosa-Amanfro	Inside a building	Slept through it	Some felt it, most did not	Moderate
Yes	Night	Kasoa	Inside a building	Slept through it	Not specified	Not specified
Yes	Night	Kasoa	Inside a building	No	Most felt it	Moderate
Yes	Night	Kasoa	Not specified	No	Some felt it, most did not	Not specified

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kasoa	Inside a building	No	Most felt it	Moderate
Yes	Night	Kasoa	Inside a building	No	No others felt it	Mild
Yes	Day	Kasoa	Inside a building	Not specified	Some felt it, most did not	Not felt
Yes	Night	Weija	Not specified	Not specified	No others felt it	Not felt
Yes	Night	Kasoa	Inside a building	Not specified	No others felt it	Weak
Yes	Night	Accra	Not specified	Not specified	No others felt it	Not specified
Yes	Night	Accra	Inside a building	No	No others felt it	Not specified

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Weija	Outside a building	Not specified	No others felt it	Mild
Yes	Night	Kasoa	Inside a building	Slept through it	Most felt it	Mild
Yes	Day	Kasoa	In a stopped vehicle	No	Not specified	Weak
Yes	Night	Kasoa	Inside a building	No	No others felt it	Not specified
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Weak
Yes	Night	Accra	Not specified	No	Everyone/almost everyone felt it	Weak
Yes	Night	Accra	Not specified	Not specified	No others felt it	Weak

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Accra	Not specified	No	Not specified	Not specified
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Not felt
Yes	Night	Kasoa	Not specified	No	No others felt it	Not felt
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Mild
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Moderate
Yes	Day	Kasoa	Outside a building	No	Everyone/almost everyone felt it	Strong
Yes	Night	Kasoa	Not specified	Not specified	Not specified	Not felt

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Weija	Not specified	Not specified	Not specified	Moderate
Yes	Day	Weija	Outside a building	No	No others felt it	Mild
Yes	Night	Kasoa	Not specified	Not specified	Not specified	Not felt
Yes	Night	Weija	Inside a building	Not specified	Not specified	Not felt
Yes	Day	Kasoa	Outside a building	Not specified	Most felt it	Mild
Yes	Night	Kasoa	Not specified	No	No others felt it	Weak
Yes	Night	Weija	Inside a building	Woke up	No others felt it	Not felt

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Weija	Not specified	Not specified	No others felt it	Mild
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Not specified
Yes	Night	Kasoa	Not specified	No	No others felt it	Not felt
Yes	Day	Weija	Outside a building	No	Most felt it	Mild
Yes	Night	Kasoa	Not specified	No	Not specified	Not specified
Yes	Night	Weija	Outside a building	Not specified	No others felt it	Moderate

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Day	Kasoa	Outside a building	No	Most felt it	Moderate
Yes	Day	Kasoa	Not specified	Not specified	Not specified	Violent
Yes	Day	Kasoa	Inside a building	Not specified	No others felt it	Strong
Yes	Day	Kasoa	Outside a building	No	Most felt it	Moderate
Yes	Day	Kasoa	Not specified	Not specified	Not specified	Not felt
Yes	Night	Kasoa	Not specified	Not specified	Everyone/almost everyone felt it	Not specified
Yes	Day	Kasoa	Outside a building	No	Most felt it	Moderate

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Day	Kasoa	Outside a building	No	Most felt it	Moderate
Yes	Night	Kasoa	Inside a building	No	Some felt it, most did not	Not felt
Yes	Night	Kwabenya	Not specified	Slept through it	No others felt it	Not specified
Yes	Day	Kasoa	Outside a building	No	Most felt it	Moderate
Yes	Day	Kwabenya	Outside a building	No	Most felt it	Weak
Yes	Day	Kasoa	Outside a building	No	Most felt it	Weak
Yes	Day	Kwabenya	Outside a building	No	Most felt it	Mild

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kwabenya	Inside a building	Not specified	Not specified	Not felt
Yes	Day	Kwabenya	Outside a building	No	Most felt it	Weak
Yes	Night	Kwabenya	In a stopped vehicle	No	No others felt it	Not felt
Yes	Day	Kasoa	Outside a building	No	Most felt it	Weak
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Not felt
Yes	Night	Kasoa	Inside a building	Not specified	Some felt it, most did not	Not felt
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Night	Kwabenya	Not specified	Not specified	Not specified	Not felt
Yes	Day	Kasoa	Outside a building	No	Most felt it	Mild
Yes	Night	Kasoa	Not specified	Slept through it	Not specified	Not felt

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kasoa	Not specified	Not specified	No others felt it	Not specified
Yes	Night	Kasoa	Inside a building	No	No others felt it	Not specified
Yes	Night	Kasoa	Outside a building	Not specified	No others felt it	Mild
Yes	Night	Kasoa Kwabenya	Inside a building	Slept through it	Most felt it	Mild
Yes	Day	Kwabenya	In a stopped vehicle	No	Not specified	Weak
Yes	Night	Kwabenya	Inside a building	No	No others felt it	Not specified
Yes	Night		Not specified	Not specified	No others felt it	Weak

Source: Field Work (2018)

Have you ever felt an earth tremor or quake?	Time of earthquake	Your location when the earthquake occurred	What was your situation during the earthquake?	Were you asleep?	Did others nearby feel it?	How would you describe the shaking?
Yes	Night	Kwabenya	Not specified	No		Weak
Yes	Night	Kwabenya	Not specified	Not specified	No others felt it	Weak
Yes	Night	Kwabenya	Not specified	No	Not specified	Not specified
Yes	Night	Kwabenya	Not specified	Not specified	No others felt it	Not felt
Yes	Night	Kwabenya	Not specified	No	No others felt it	Not felt
Yes	Night	Kwabenya	Not specified	Not specified	No others felt it	Mild

Source: Field Work (2018)