International Journal of Inventive Engineering and Sciences (IJIES)
ISSN: 2319-9598 (Online), Volume-12 Issue-11, November 2025

Seismic Station RA086 Statistical Analysis of Earthquake Data Using Shake Net and Grapher on the Global Seismic Activity: Analyzing Earthquake Patterns, Clustering, and Implications for Hazard Assessment

Mohammed Ali Garba, Barka Jonathan, Edwin Yenika Mbiimbe, Kamureyina Ezekiel, Mustafa Ali Garba

***Abstract:** The paper examines earthquake activity in 2023 using data from the active seismic station RA086 in the city of São Tomé. Five thousand and twenty-four (5,224) events of earthquakes were observed and processed with ShakeNet software and Grapher. On May 20, 2023, a strong earthquake of magnitude 7.6 was reported in the Pacific Ocean, off the coast of the Tanimbar Islands in Indonesia, at a depth of 105 km, and was followed by frequent earthquakes. The data reveal the distribution of earthquakes around the world, which is mainly concentrated in tectonic hotspots like the Pacific Ring of Fire, with magnitudes ranging from very large (7.6) to moderate. The earthquakes varied greatly in depth, ranging from shallow crustal earthquakes to deep-seated, long-focus earthquakes in the subduction zone, with depths over 500km. The analysis also shows frequent coalescence of mainshocks and aftershocks, particularly in subduction trenches, indicating continuous tectonic processes. Another aspect highlighted by the data is that both shallow and deep seismic events should be monitored, as energy released at different depths can affect surface shaking and the potential for disaster.*

***Keywords:** Seismic Activity, Shakenet, Tectonic Zones (Mantle Transition Zone (MTZ, MW -Movement Magnitude)*

Nomenclature:
MTZ: Mantle Transition Zone
TIRI: Tanimbar Island Region, Indonesia
STZ: Shakenet, Tectonic Zones

I. INTRODUCTION

In 2023, the active station of São Tomé (RA086) recorded seismic records (more than 5,200) of earthquakes all over the world. The ShakeNet analysis detected a magnitude 7.6 earthquake near the Tanimbar Islands in Indonesia. It outlines the modern tectonic processes at the global scale, including the formation of subduction zones and faults, and the movement of the planet's active crust.

The registered earthquakes ranged from shallow crust tremors to deep-focus quakes, which were greater than 500km deep. Major deep earthquakes were felt in potential active regions such as the Kermadec Islands and Fiji, which result from active subduction. Such distributions and event clustering depict the complex mechanism of interaction among tectonic plates, and a mainshock-aftershock sequence predominates in active zones.

The statistics justify the need for permanent seismic monitoring, especially in high-hazard areas such as the Pacific Ring of Fire. More advanced forms of analysis, including clustering and time-series modelling, enhance understanding of earthquakes, making real-time risk assessments easier. The data is crucial for supporting preparedness and countering the impact of future earthquakes worldwide.

The 2025 Mw 7.7 earthquake on the Sagaing Fault was due to oblique convergence of the Indian and Burmese Plates, and it had a shallow supershear rupture with surface displacement exceeding 6 m. It caused severe shaking, more than 4,900 deaths, and widespread infrastructure damage, highlighting acute shortcomings in seismic preparedness and the need for a more effective mitigation strategy [1]. Near-source strong-motion data are effective for determining rupture directivity in small earthquakes. Examination of the 2024 Feidong M4.7 earthquake, with a station 4 km south of the epicentre, revealed a 40 ° rotation of S-wave polarisation associated with rupture propagation to the southwest on the Tanlu fault. This polarisation change was found to be source-related and confirmed by comparison with synthetic waveforms and local M3 events, underscoring the importance of close-in observations for characterising rupture characteristics in small earthquakes [2]. The amount of material increases in rocks during deformation, a phenomenon first investigated in granular geomechanics and since then used to describe the behaviour of brittle rocks and to predict earthquake precursors using the dilatancy-diffusion hypothesis. This theory connects earthquake triggering to changes in rock volume and pore pressure, but it has drawbacks when scaling experiments to the Earth's crust. Recent progress

Manuscript received on 21 October 2025 | First Revised Manuscript received on 30 October 2025 | Second Revised Manuscript received on 08 November 2025 | Manuscript Accepted on 15 November 2025 | Manuscript published on 30 November 2025.
*Correspondence Author(s)
Mohammed Ali Garba*, Department of Geology, Gombe State University, Gombe, Nigeria, Email ID: mohammedaligarba@gsu.edu.ng, ORCID ID: 0000-0001-6247-8702
Dr. Barka Jonathan, Department of Geology, Gombe State University, Gombe, Nigeria, Email ID: joebarka@gsu.edu.ng, ORCID ID: 0009-0003-9861-6339
Dr. Edwin Yenika Mbiimbe, Department of Geology, Gombe State University, Gombe, Nigeria Email ID: edwinyenika2016@gsu.edu.ng
Dr. Kamureyina Ezikiel, Department of Geology, Adamawa State University, Mubi, Adamawa State, Nigeria, Email ID: kamureyina123@gmail.com, ORCID ID: 0000-0002-4803-7772
Mustafa Ali Garba, Department of Physics, University of Maiduguri. Nigeria, Email ID: mustaphaaligarba@gmail.com, ORCID ID: 0009-0004-9655-0855

in deep learning, especially physically inspired neural networks, offers potential solutions for integrating this physical knowledge into more effective earthquake prediction schemes, which can have a beneficial impact on seismic risk mitigation and early warning systems [3].

There is also the problem of a lack of monitoring stations in Africa, so the information may not be received when a station malfunctions [4]. A parochial way of thinking seeks to reduce the magnitude of earthquakes by controlling seismic foci with microwave irradiation. Yet, the magnetic-hydrodynamic radiation approach for precisely locating earthquake foci is not viable. Although the theoretical discussion is usually substantiated by empirical evidence, high-frequency earthquake areas are associated with specific geologic structures, including trenches and volcanic regions. Tidal activity and Earth's rotation favour the association between seismic activity and Earth's rotational dynamics. The prediction of earthquakes would be enhanced in future through additional research on solar tidal effects and harmonic-based prediction. Still, few studies have been conducted based on harmonic [5]. Seismology predicts the occurrence of earthquakes using chemical physics and mechanics, but it is hard to grasp. Others include releasing energy through microwaves, which is not practised [6]. The article discusses a limited approach to reducing earthquake size by controlling seismic focus via microwave irradiation. Magnetohydrodynamic generator radiation cannot be used to determine the focus of the next earthquake, despite advances in tectonic physics. The author accepts this depressing conclusion, which aligns with the tendency in seismology to focus on monitoring and search-and-rescue solutions [7].

The liquid potential in the soil in the Rohingya refugee camp area in Ukhiya, Bangladesh, based on the Standard Penetration Test result, and Liquefaction Potential Index. The sandy soil containing silty clay falls into the highest risk category, indicating that it is susceptible to earthquakes of magnitude 5.0 and above, extending to 10 meters in depth and up to 15 meters in magnitude. The paper reveals that sustainable geotechnical interventions and risk mapping must also be implemented to help prevent potential environmental and humanitarian catastrophes. This paper suggests that the Alfven solitary wave could be a good predictor of earthquakes, based on pattern analysis of electromagnetic waves detected by Ada over the past 20 years. But since this cannot be seen, it should be determined by the very talented scientists in astrophysics and seismology using sophisticated machinery [8].

Because distinguishing genuine reactions from noise can be challenging, seismologists often ignore the link between animal behaviour and earthquake precursors. Some people in China can sense the beginnings of earthquakes, which facilitates communication and provides factual evidence of this occurrence. The project's objective is to develop earthquake prediction systems inspired by biological processes, while accounting for the complexity of the human brain. Future advancements in human frontier technology may result from a better understanding of the body's remarkable capacity to detect seismic precursors. Cao [9]. The analysis of 2023 earthquake data demonstrated that the world exhibits a distinct seismic pattern, with December the most active month, possibly due to climatic conditions. Large earthquakes tend to occur along tectonic boundaries, notably the Pacific Ring of Fire, whereas intraplate earthquakes reveal intricate changes. Hazard comprehension, when multiplied by different magnitudes and temporal variations, enhances hazard mitigation. Issues with understanding the deeper causes of the rise in earthquake frequency in December are among the research gaps the article raises. The possible impacts of long-term climatic processes, as well as the anthropogenic earthquake angle, are also lacking. Singh [10]. Andrea et al. [11] demonstrate that real-time estimation of large earthquakes with magnitudes above 8 is feasible using speed-of-light elastogravity signals, aiding early warning and tsunami mitigation. Using deep learning on synthetic and real data, it analyses signals preceding seismic waves to monitor the growth of earthquakes. Simulations since 2003 show that PEGSNet can estimate final magnitudes within minutes for significant events, though accuracy diminishes for minor quakes near the sensitivity limits. Magneto-plasticity plays a crucial role in the magnetic control of earthquakes, where microwaves advance dislocations, releasing elastic energy that can trigger seismic events. Microwave receivers and even microwave emitters that are continuous generators are the foci of the earthquake. Seismic activity interacts with microwaves, thereby regulating their production and accelerating crack development. The mobility of dislocations is affected by magnetic control, which converts elastic energy into plastic deformation, which may eventually reduce the strength of an earthquake. This two-fold mechanism may be studied to help research the dynamics of earthquakes, and it may have the potential to remove high-energy events and trigger low-magnitude events.

An explanation can be found in the mantle transition zone (MTZ) beneath Kamchatka to the effect that there is significant topographical dissimilarity in depths of 410- and 660-kilometres discontinuities, with 410 having uplifts of 45 65 kilometres and depths of 15 37 kilometres respectively and the depths of the 660 displaying something about the aberrations of low temperature. Such characteristics indicate significant slab heating in the MTZ, probably via hot mantle flows through a torn slab window, with implications for the thermal and rheological properties of the subducting slab and, thus, for slab dynamics in the northwestern Pacific [12]. The 2025 southwestern Taiwan earthquake (ML 6.4) was a complex rupture involving antithetic thrusts of the fold-and-thrust belt, an east-dipping forethrust, and a west-dipping backthrust. Aftershock distributions and fault slip modelling indicated that these faults were activated concurrently and were directly linked to intense rupture directivity to the southwest, which was accompanied by large-scale building damage. Such insights are limited to knowledge of the dynamic rupture process and stress-transfer mechanisms in concurrent ruptures of segmental conjugate faults; further research should use high-resolution geodetic data and dynamic rupture modelling to enhance understanding of fault linkage and seismic hazard in compressional tectonic systems [13]. The northern Chile subduction zone (2014–2019) shows complex seismicity: a shallow double zone with a gap, clustering between 80–150 km, and deep isolated clusters. These patterns are linked to slab hydration, metamorphic reactions, tension, and ridge subduction. But multidisciplinary research is

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

needed to understand the physical mechanisms, including slab tension and metamorphic processes, driving earthquake clustering [14].

II. METHOD AND DATA

In 2023, 5,224 Earthquake data points were collected from an active station (RA086) in São Tomé (0.1864°N, 6.6131°E) with an elevation of 43 m above sea level. Using ShakeNet, the data were analyzed using Grapher. On 20/05/2023, a great earthquake of 7.6 Reickter scale was registered at 17:47:35 at a depth of 105km, located 11105km (Tanimbar Island Region, Indonesia) from the active Seismic station RA086 in Sao Tome. We can quantify surface detail on Earth, but when we delve into its crust, we lose sight of the secrets beneath. All continents and oceans experience daily vibrations due to Earth's crust cracking and evolving, as explained by our new understanding of gravity. Earth's secrets remain unexplored even as numerous earthquakes occur worldwide each day. From August 2021 to December 2021, ShakeNet software was used to track earthquakes with magnitudes larger than or equal to four Reikter scale, uncovering the secrets of Earth's quakes and the risks they pose to human life and property. Three thousand seven hundred nine recorded earthquakes in 2021 were the result of five distinct occurrences. The deepest and shallowest earthquakes, measuring 497 meters and 0 meters, respectively, occurred in the Chile-Argentina Border Region on October 21. Africa's monitoring stations occasionally experience outages. Seismic investigations reveal numerous factors impacting earthquake frequency and intensity.

Table I: Data Showing the Magnitude, Time, Depth, Distance, and Place of the Shaking

Date	Magnitude(M)	Time	Depth(km)	Distance(km)	Place
09/01/2023	7.6	17:47:35	105km	11105km	Tanimbar Isl Region, Indonesia
20/05/2023	7.1	1:51:01	36km	17399km	Southeast of Loyal Islands
21/05/2023	6.8	14:56:45	10km	6624km	Prince Edward Islands Region
"	6.9	6:41:22	206km	6645km	Kermadec Isl, New Zealand
07/03/2023	6	6:02:34	39km	12504km	Mindanao, Philippines
"	6	13:51:49	10km	15132km	New Ireland region, PNG
06/02/2023	5.8	20:59:59	526km	18047km	Fiji Islands region
"	5.8	7:33:09	60km	5321km	Solomon Islands
12/03/2023	5.7	7:43:20	10km	16790km	Santa Cruz Islands
03/03/2023	5.6	4:53:55	10km	10km	East of the South Sandwich Islands.
"	5.6	8:47:42	10km	55342km	Mindanao Philippines
08/03/2023	5.6	6:03:36	36km	9939km	Kuril Islands
03/03/2023	5.5	19:00:26	10km	51km	Northern Chile
"	5.4	20:43:02	10km	6512km	Mindanao, Philippines
07/03/2023	5.4	20:31:29	45km	13002km	Southern Molucca Sea
08/03/2023	5.4	13:43:23	10km	13214km	W. Caroline isl, Micronesia
11/03/2023	5.4	9:18:41	159km	8019km	Northern Colombia
03/03/2023	5.3	0:54:27	10km	10km	Vanuatu Islands
07/03/2023	5.3	7:31:57	43km	11721km	Southwest of Sumatra, Indonesia.
"	5.3	20:46:05	15408km	11234km	New Britain Region, PNG
08/03/2023	5.3	8:32:17	495km	18525km	South of the Fiji Islands
12/03/2023	5.2	0:31:53	13km	11051km	East of the South Sandwich Islands
"	5.2	1:53:24	10km	5432km	Near the Coast of Peru
03/03/2023	5.2	9:41:17	51km	51km	Solomon Islands
"	5.2	20:18:07	46km	6743km	Samoa Islands Region
08/03/2023	5.2	16:10:50	10km	9835km	Off the East Coast of Kamçhatka
"	5.2	1:09:12	10km	19954km	South Sandwich Isl. Region
13/03/2023	5.2	22:50:45	137km	10160km	La Rioja Province Argentina
3/03/2023	5.1	0:54:47	62km	62km	Southern Sumatra Indonesia
"	5.1	19:25:43	57km	10km	Near the Coast of Peru
	5.1	22:24:48	48km	565km	Hokkaido, Japan region
12/03/2023	5.1	20:56:51	9km	16694km	Santa Cruz Islands
13/03/2023	5.1	19:19:15	104km	9570km	Near the coast of Peru
"	5	2:53:43	10km	54321km	Turkey
"	5	1:19:32	19km	4321km	South of the Kermadec Islands
6/02/2023	5	7:34:49	35km	10559km	Near the coast of central Chile
"	5	9:25:49	10km	11439km	Scotia sea
7/03/2023	5	3:59:39	9km	8507km	Near the west coast of Colombia
08/03/2023	5	0:58:51	12km	14952km	New Guinea, P. New Guinea
"	5	4:54:52	162km	9212km	Peru-Brazil border region
11/08/2023	5	11:00:57	23km	15355km	New Britain region
13/02/2023	5	6:11:33	551km	17680km	Fiji Islands region
"	5	13:40:51	10km	19211km	Kermadec Islands region
"	5	21:46:06	10km	16792km	Santa Cruz Islands

From Table 1, the 2023 earthquake data distinguish various earthquakes, primarily concentrated in tectonically active areas, including Indonesia, the South Pacific, Papua New Guinea, and certain sections of South America. The largest earthquake

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

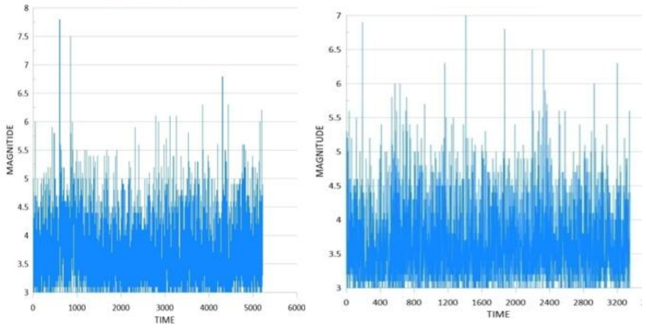
observed was a 7.6 magnitude on 9th January, just off the Tanimbar Islands, Indonesia, at an intermediate depth of 105 km. There were also other major earthquakes with a magnitude of 7.1, 36 km northeast of the Southeast of Loyal Islands at a depth of 36 km, a 6.9 high-to-deep focus earthquake at 206 km in the Kermadec Islands, and a deep, 6.8 magnitude earthquake at a low depth at the Prince Edward Islands Region. Numerous moderate earthquakes (magnitude 5.0-5.8) occurred across the Pacific Ring of Fire, including the Philippines, Fiji Islands, Solomon Islands, South Sandwich Islands, and South America, indicating continued strain release along major plate boundaries. The depth of events is wide-ranging, ranging from very shallow earthquakes measuring about 10km, typifying crustal tremors capable of significant surface shaking, to intense events over 500km in the Fiji region that reflect a sophisticated subduction process. The listed distances, which range from as close as to thousands of kilometres away, are most likely distances to monitoring stations or reference points. All in all, the statistics indicate a lively year of earthquakes, with moderate tremors occurring regularly and a few megathrust earthquakes in the subduction zone, reminding the world of current hot-spot scenarios and the need to keep up with seismic observatories in these areas.

III. RESULTS

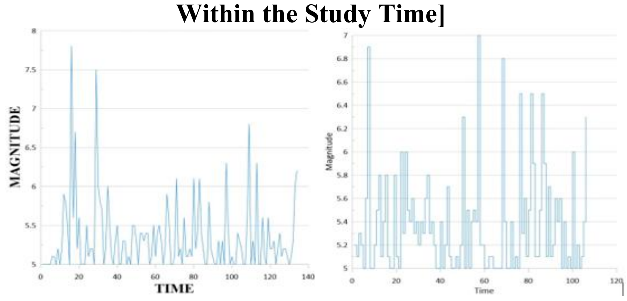
From Table 2, the earthquake data indicate intense seismic activity in regions of large tectonic boundaries, particularly subduction zones. Interesting quakes include a magnitude 7.6 event near the Tanimbar Islands, Indonesia, and a series of others with magnitudes between 5.0 and 7.1 at different depths, which indicate various geodynamic processes. The dynamics of the interplay between shallow and deep seismicity along active plate margins worldwide are well illustrated by these earthquakes, underscoring the need to continuously monitor such areas.

Table II: Intensity of Earthquake During the Study Period

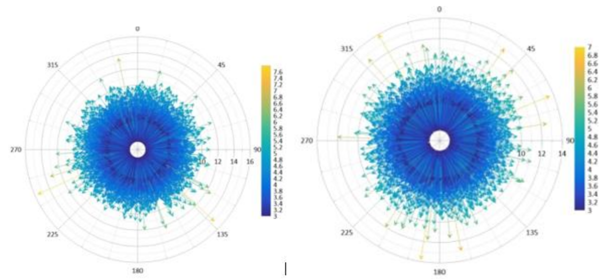
Place	Latitude	Longitude	Magnitude	Depth
Animbar Islands Region, Indonesia	-7.0	131.0	7.6	105
Southeast of Loyal Islands	-20.0	167.0	7.1	36
Prince Edward Islands Region	-46.6	37.8	6.8	10
Kermadec Islands, New Zealand	-29.3	178.0	6.9	206
Mindanao, Philippines	7.0	125.0	6.0	39
New Ireland region, PNG	-3.6	152.5	6.0	10
Fiji Islands region	-17.7	178.4	5.8	526
Solomon Islands	-9.6	160.2	5.8	60
Santa Cruz Islands	-10.7	165.8	5.7	10
Kuril Islands	49.0	156.5	5.6	36
Northern Chile	-22.9	-70.0	5.5	10
Turkey	39.0	35.0	5.0	10
Scotia Sea	-60.0	-45.0	5.0	10



[Fig.1: The Generalised Magnitude of the Earthquake Within the Study Time]



[Fig.2: An Example of 2 Months of Seismic Magnitudes]



[Fig.3: An Example of a Point Vector Plot Display of 2 Months of Seismic Data]

As shown in Table 3, the earthquakes in 2023 comprise a diverse mix, primarily in tectonically active areas associated with subduction zones and complex plate boundaries. The biggest was a magnitude 7.6 earthquake near the Tanimbar Islands in Indonesia on January 9, occurring at a depth of 105 km, typical of megathrust subduction earthquakes. A second detail was a Magnitude 7.1 near the Loyalty Islands on May 20 at a shallow depth of 36km, showing how surface locations are at risk of strong seismic shaking and even tsunamis. Other interesting deep and abnormal earthquakes in the data set include magnitudes 6.9 along the Prince Edward Islands, on May 21, which was unexpected in a less active region, and deep-focus earthquakes, such as magnitude 6.8 along the Kermadec Islands at 206 km depth, and a magnitude 5.8 in Fiji at 526 km depth, showing the aspect of active subduction processes deep in the earth's crust. Substantial tectonic adjustments were manifested throughout the year in moderate earthquakes (magnitudes 5.0- 5.7). In general, seismic activity this year shows the complicated and diverse character of the tectonic systems of our planet in various areas.

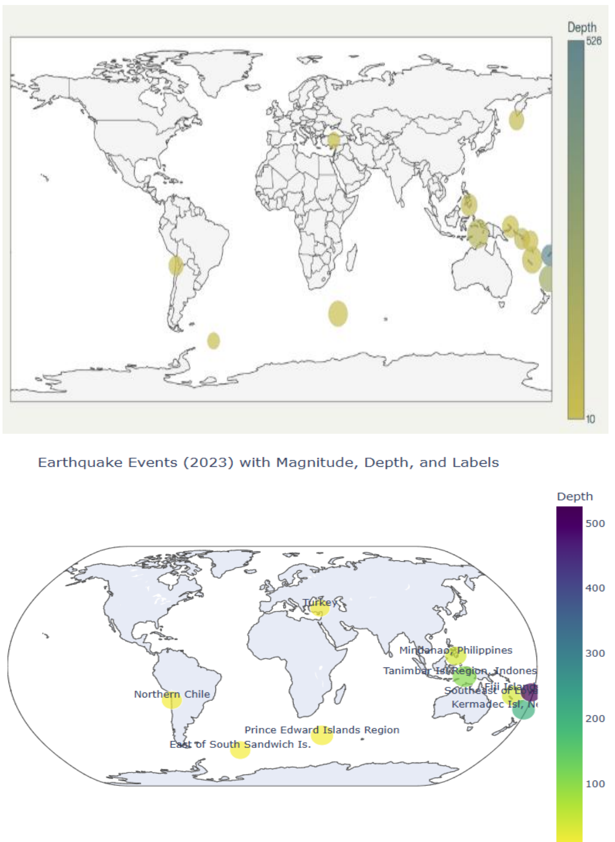
Retrieval Number: 100.1/ijies.K112812111125
DOI: 10.35940/ijies.K1128.12111125
Journal Website: www.ijies.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

International Journal of Inventive Engineering and Sciences (IJIES)
ISSN: 2319-9598 (Online), Volume-12 Issue-11, November 2025

Table III: Key Earthquake Locations

Date	Magnitude	Depth (Km)	Location	Description
09/01/2023	7.6	105	Tanimbar Region, Indonesia	Large subduction quake
20/05/2023	7.1	36	Southeast of Loyal Islands	Significant quake near the subduction
21/05/2023	6.9	10	Prince Edward Islands Region	Shallow in an unusual zone
“	6.8	206	Kermadec Islands, NZ	Deep-focus subduction event
06/02/2023	5.8	526	Fiji Islands region	Intense earthquake
Various	5.0 -5.7	Various	Multiple locations	Widespread moderate seismic activity



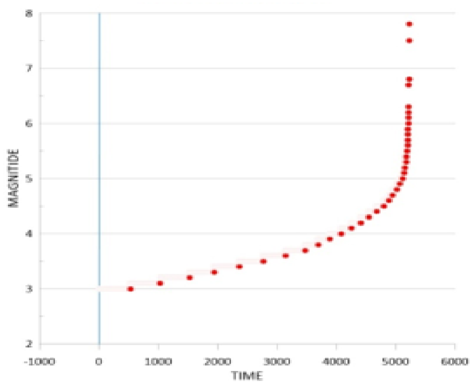
[Fig.4: World Earthquake Map Showing the Seismicity (Online Colab. Research. Google. Com)]

Table 4 displays the 2023 data on earthquakes, and Figures 6, 7, 8, 9, 10, and 11, which have a series of earthquakes with a combination of both mainshocks and rumbles, primarily concentrated in zones of tectonic activity and a few misattributed or isolated searches. Justifiably, a strong mainshock of magnitude 7.6 was recorded on January 9th at a latitude of -7.0 and longitude 131.1, which was recognized as cluster 0. This earthquake produced at least one major aftershock of magnitude 5.5 on January 10th, at a nearby location and time, which is typical of the aftershock activity that follows a large earthquake. It is the same case with the occurrences of the secondary mainshock of 6.0 on March 7th, lat. 7.0 and long. 125.0 (cluster 1) as well as of subsequent mainshocks of 5.2 and 5.0 on March 7th and 8th, respectively, which were experienced with the same seismic sequence modes. These mainshock-aftershock pairings emphasise standard processing in the functional zones of active subduction and fault zones, where locally initiated stress adjustment triggers several associated events.

On the contrary, several events are not identified in any cluster (marked cluster -1), and they are a magnitude 7.1 quake on May 20th at latitude -20.0 and longitude 167.0, and a 6.8 magnitude quake on May 21st at latitude -46.6 and longitude 37.8. The fact that they are isolated in clustering analysis indicates they could not have a set of well-timed or well-located associated foreshocks or aftershocks. It therefore might indicate either unrelated or independent seismic activity or incomplete data-related associations. Likewise, a smaller magnitude 4.9 occurrence on June 1st at latitude 35.0, longitude 70.0 is not associated with any cluster. On the whole, this dataset displays a complex seismic field with distinct major shock-to-aftershock sequences coexisting with scattered, possibly independent earthquakes, supporting the inconsistent and geographically/regionally varying aspects of earthquake occurrence and clustering mechanics.

Table IV: Showing the Date, Time, Magnitude, Longitude, Latitude, Cluster, and Category for the Seismic Shocks

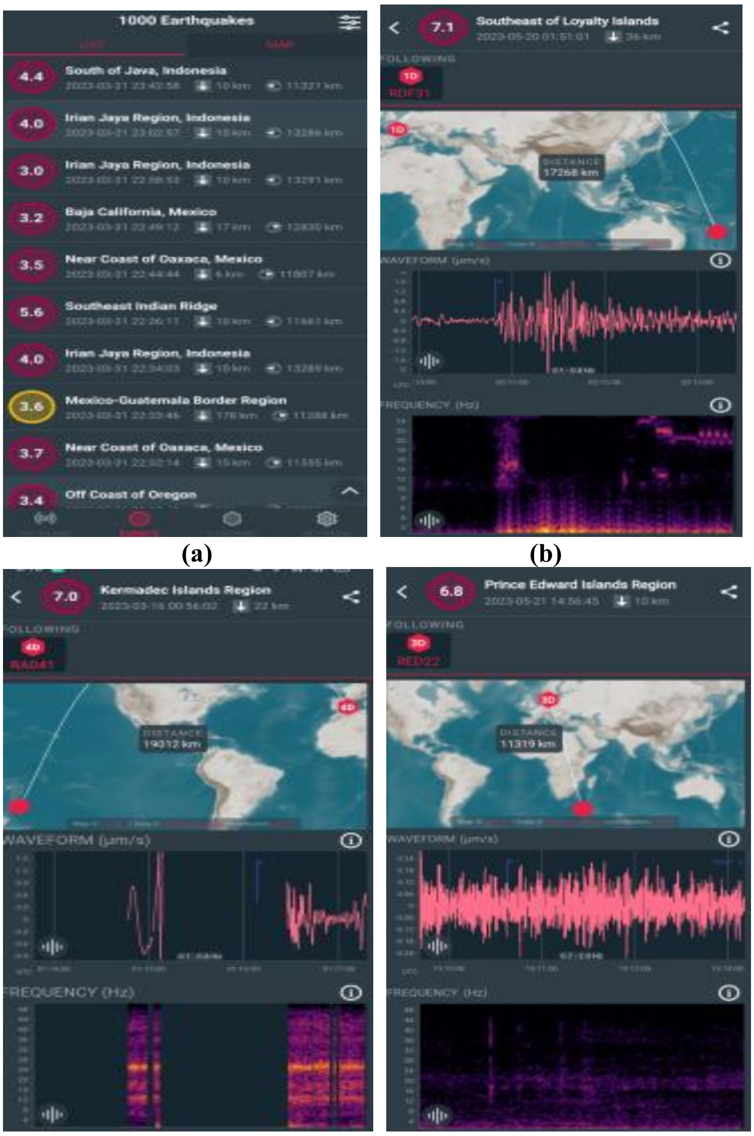
Date	Time	Magnitude	Latitude	Longitude	Cluster	Category
20/05/2023	01:51:01	7.1	-20.0	167.0	-1	Unrecognized
21/05/2023	14:56:45	6.8	-46.6	37.8	-1	Unrecognized
01/06/2023	10:00:00	4.9	35.0	70.0	-1	Unrecognized
09/01/2023	17:47:35	7.6	-7.0	131.1	0	Mainshock
10/01/2023	12:00:00	5.5	-7.1	131.0	0	Aftershock
07/03/2023	06:02:34	6.0	7.0	125.0	1	Mainshock
07/03/2023	08:00:00	5.2	7.2	125.4	1	Aftershock
08/03/2023	07:00:00	5.0	6.9	124.9	1	Aftershock



[Fig.5: An Example of the Statistical Distribution of the Seismic Data]

Retrieval Number: 100.1/ijies.K112812111125
DOI: 10.35940/ijies.K1128.12111125
Journal Website: www.ijies.org

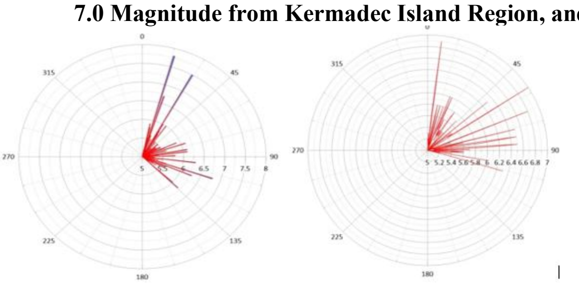
Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)



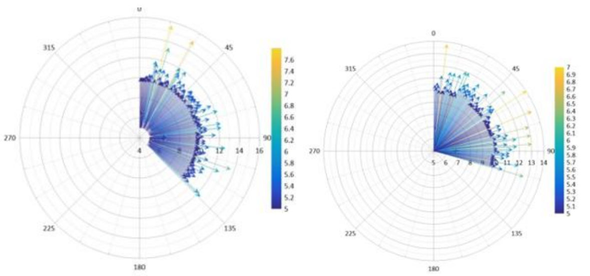
(a) (b)

(b) (d)

[Fig.8: (a) Data from ShakeNet Showing Display of Seismic Data, (b) 7.1 Magnitude from Southeast Loyalty Islands, (c) 7.0 Magnitude from Kermadec Island Region, and (d) 6.8 Magnitude from Prince Edward Islands Region]



[Fig.6: Rose Plots of the Seismic Signals]

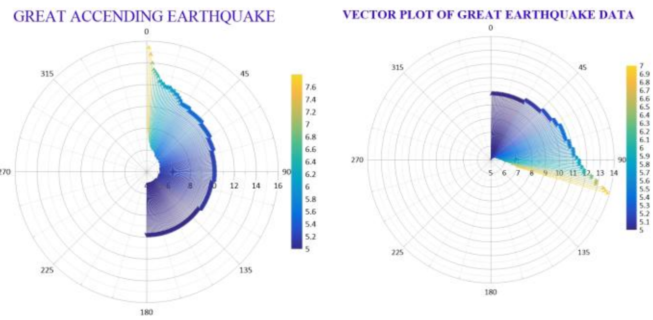


[Fig.7: Vector Plots of the Seismic Signals]

[Fig.9: The Strongest Magnitude of 7.6 Recorded by Station RBD 70 Happened at the Tanimbar Islands Region of Indonesia at a Depth of 105km at Exactly 17:47:35 on 09/01/2023]

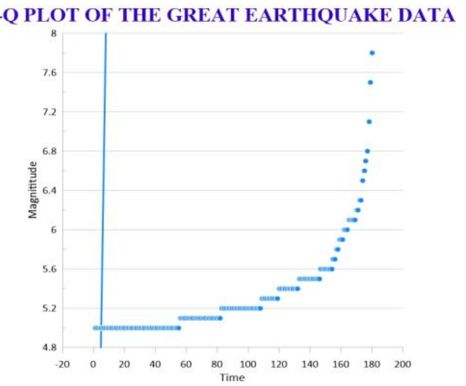
Retrieval Number: 100.1/ijies.K112812111125
DOI: 10.35940/ijies.K1128.12111125
Journal Website: www.ijies.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)



(a) (b)

[Fig.10: (a) The Great Ascending Earthquake and (b) The Vector Plot of the Great Ascending Earthquake]



[Fig.11: The Q-Q Plot of the Great Earthquake]

[Fig.12: Display of the 7.6 Magnitude Shown by the US Geological Survey (USGS) (Internet 2024)]

It is observed in the earthquake dataset in the year 2023 that there is a lot of seismic activity that is centred mainly around tectonically active places, which are well-known, like the Pacific Ring of Fire, which includes the Fiji Islands region, Indonesia, the Philippines, Papua New Guinea, and East Timor Figure 11. It has experienced earthquakes ranging from moderate (approximately 5.0) to very strong (up to 7.6), the largest being a 7.6 on the 9th of January near the Tanimbar Islands of Indonesia. They range from very shallow (usually less than 10 km) to very deep (over 500 km), depending on the various tectonic processes (both shallow crustal faults and deeper subduction zone earthquakes). Most of the events occur along fault zones and subduction trenches, indicating active tectonic collision in these regions. The time distribution suggests aggregated bursts of activity, as evidenced at the beginning of March and May 2023, with possible sequences of foreshocks and aftershocks.

Regarding seismic hazard, the magnitude, depth, and timing of the data can help interpret earthquake patterns and identify potential risk areas. Big boulder earthquakes occur quite often at inclined depths, which are highly dangerous because the energy released in subduction zones and shallow earthquakes can produce strong surface vibrations. The differences in distance, along with the presence of deep-focus earthquakes in regions such as Fiji, also illustrate the multiplexity of the geodynamic processes involved. The techniques under consideration are time-series analysis and data clustering, which enable the identification of groups of related earthquakes and the distinction between mainshocks, foreshocks, and aftershocks based on their spatiotemporal proximity and magnitude relationships. The classification helps understand seismic sequences, which is essential for better real-time earthquake risk assessment and preparedness decisions.

IV. DISCUSSION

The paper under consideration is an in-depth analysis of the earthquake scenario observed in any region of the world in 2023, which is, first of all, based on the results of the active seismological station RA086 in the city of Sidney on the island of that name, as well as ShakeNet and Grapher software with which the results are processed. The discussion of 5,224 seismic events provides extensive explanations of the spatial separation, temporal occurrence, size, depth range, and concentration patterns of earthquakes worldwide, especially in tectonically active regions such as the Pacific Ring of Fire. One outcome is that a significant magnitude 7.6 earthquake occurred at the Tanimbar Islands, Indonesia, on January 9, 2023, at an intermediate depth of 105 km, within a tectonically complex subduction zone. This occurrence is a good example of what a high-sensitivity, well-situated earth station like RA086 (with a distance to the source exceeding 11000km) can observe and characterise during total seismic tracking. The earthquake data reported in this range show significant variations in magnitudes, ranging from moderate (25- 5.0) to constructive vast (7.6) and depths, starting with deep crustal earthquakes (25 10 km) and extending down to very deep-focus earthquakes (greater than 500 km in areas such as Fiji). The complexity of geodynamic processes, including crustal faulting and subduction dynamics, is evident at this scale. Interestingly, the fact that deep-focus earthquakes occur just vindicates the active subduction and mantle interactions, which do not refute the current bodies of knowledge of the geophysical community that deep seismicity effectively relates to the dynamics of the slab's descent in subduction zones. The other important observation is that the seismic events are clustered over time. The data represent incidences of high seismic activity, specifically burst sessions in early March and May 2023, during which many mainshock-aftershock series occurred. The clustering analysis distinguishes between known clusters (sequences of the mainshocks that involved foreshocks and aftershocks) characteristic of active subduction zones and isolated seismic events that may be isolated or indicative of data gaps. This difference plays a fundamental role in real-time earthquake risk evaluation and prediction, as the pattern of stress release can be determined and regions at risk of aftershocks identified.

In hazard terms, the results also show that both shallow and deep seismic processes should be carefully monitored. Earthquakes close to the surface are more likely to cause damage, as their ground shaking can be intense. In contrast, deep earthquakes can be significant, affecting processes deep in the Earth and possibly influencing seismic hazard through interactions with complex stresses. The spatial distribution that revolves around recognised tectonic hot spots such as Indonesia, the South Pacific, Papua New Guinea, and some areas of South America supports models of global seismicity, which correlate high earthquake frequency with active plate boundaries and specific subduction trenches and fracture zones. The paper's argument for the achievability of better seismic monitoring and analysis methods is quite valid. The ShakeNet and Grapher programs were used to provide robust event identification and description. However, the authors recommend a larger extension to include more sophisticated approaches such as sequential clustering and online descriptive modelling. These methods are also gaining wider use in seismology and have the potential to enhance predictability by identifying trends in earthquake series, enabling risk assessment and preparedness. The results align with the seismology literature. The inadequacy of simple Poisson models to predict earthquake occurrence and the value of clustering and statistical models in explaining aftershock behaviour have been highlighted by Harsh Malviya (2025). Adding to this scheme are the interdependencies among tectonic forces, solar-terrestrial influences, and crustal heterogeneity, which make earthquake forecasting even more complex (as observed in the reviewed literature). The trend of modern earthquake science is apparent in recent developments in machine learning, such as real-time magnitude estimation (e.g., PEGSNet for large earthquakes), and in new physical models, such as magneto-plasticity. A key setback of the research is the reliance on data from a single seismic station, which may limit the spatial resolution and completeness of earthquake detection, potentially affecting the comprehensiveness of the global seismic activity analysis.

A. Summary

The research is a detailed investigation of the 2023 earthquakes, as measured at the active station RA086 in the city of São Tomé, using ShakeNet and Grapher software to analyse the data. Consisting of more than 5,200 recorded events, the findings indicate a wide range of seismic activity worldwide, especially in tectonically active regions such as the Pacific Ring of Fire. Earthquake statistics identify earthquakes ranging from minor to very large (7.6), comprising moderate to large earthquakes. In contrast, the occurrence of both seismic events and mainshock-aftershock pairs is highly variable and requires continuous monitoring at broad scales, both shallow and deep.

V. CONCLUSION

The results point to the extreme necessity of permanent seismic monitoring and the development of more precise analytical tools to understand earthquake patterns and risk better. The identification of clustering trends and shallow-deep interaction can improve real-time hazard evaluation and preparation plans. The study provides a classic example of how the combination of precise data at its core with advanced methods of analysing information can enhance our forecasts and planning to better manage the effects of earthquakes and properly manage disaster risk in seismically active areas around the globe. A key limitation of the study is reliance on data from a single seismic station, which may limit spatial coverage and the ability to fully detect earthquakes, affecting the overall understanding of global seismic activity. To improve the research, incorporating data from multiple stations worldwide, utilising advanced multi-station and real-time data integration, and applying machine learning techniques can enhance spatial resolution, detection accuracy, and predictive capabilities.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/ Competing Interests:** Based on my understanding, this article has no conflicts of interest.
- **Funding Support:** This article has not been funded by any organizations or agencies. This independence ensures that the research is conducted with objectivity and without any external influence.
- **Ethical Approval and Consent to Participate:** The content of this article does not necessitate ethical approval or consent to participate with supporting documentation.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Author's Contributions:** The authorship of this article is contributed equally to all participating individuals.

REFERENCES

1. Harsh Malviya (2025). Earthquake Pattern Analysis Using Clustering, Forecasting, and Machine Learning: A Global Study (1960–2023) Journal of Research in Environmental and Earth Sciences Volume 11 ~ Issue 6 (June 2025) pp: 84-91 ISSN(Online):2348-2532 www.questjournals.org
2. Yu, C., Li, Z., Hu, X. *et al.* Source Characteristics and Induced Hazards of the 2025 *M*6.8 Dingri Earthquake, Xizang, China, Revealed by Imaging Geodesy. *J. Earth Sci.* **36**, 847–851 (2025). DOI: https://doi.org/10.1007/s12583-025-0175-8
3. Zhu, Z., Jiang, Z., Accornero, F., and Carpinteri, A.:

Correlation between seismic activity and acoustic emission based on in situ monitoring, Nat. Hazards Earth Syst. Sci., 24, 4133–4143, DOI: https://doi.org/10.5194/nhess-24-4133-2024, 2024

4. Mohammed. Ali Garba (2022): Global Natural Disasters: An Earthquake Assessment, International Journal of Innovative Science and Research Technology, ISSN No: -2456-2165, Volume 7, Issue 12, Pp. 880- 889. https://www.ijisrt.com/assets/upload/files/1670514241.pdf
5. Buchachenko, A. (2022). Self-Excitation of the Earthquakes. *Open Journal of Earthquake Research*, 11, 18-30. DOI: https://doi.org/10.4236/ojer.2022.111002
6. Zhao, S. (2023). Earthquake, Volcano, and Earth Rotation Harmonics. *Open Journal of Earthquake Research*, 12, 139-158. DOI: https://doi.org/10.4236/ojer.2023.123005
7. Buchachenko, A. (2023). Earthquake under Control: Is It Feasible? Open Journal of Earthquake Research, 12, 159-176. DOI: https://doi.org/10.4236/ojer.2023.124006
8. Hossain, A., Mahabub, M., Dutta, T., Khatun, M., Terao, T., Imam, M., Sayem, H., Haque, M., Khan, P. and Jafrin, S. (2023) The Hidden Earthquake Induced Liquefaction Risks in the Rohingya Refugee Camp Hills & Surrounding Areas of Ukhiya, Cox's Bazar, Bangladesh—A Geotechnical Engineering ApproachThe Hidden Earthquake Induced Liquefaction Risks in the Rohingya Refugee Camp Hills & Surrounding Areas of Ukhiya, Cox's Bazar, Bangladesh—A Geotechnical Engineering Approach. *Open Journal of Earthquake Research*, 12, 114-138. DOI: https://doi.org/10.4236/ojer.2023.123004
9. Cao, D. (2023). An Attempt to Analyse a Human Nervous System Algorithm for Sensing Earthquake Precursors. *Open Journal of Earthquake Research*. 12, 1-25. DOI: https://doi.org/10.4236/ojer.2023.121001
10. Singh L. (2024): Insights into Global Earthquake Activity: Analysis of Global Earthquakes in 2023. RPubs - Insights into Global Earthquake Activity: Analysis of Global Earthquakes in 2023. https://rpubs.com/mleena2/1180639
11. Andrea Billi, Fabio Corbi, Marco Cuffaro, Barbara Orecchio, Mimmo Palano, Debora Presti & Cristina Totaro. (2024): Seismic slip channelling along the East Anatolian Fault illuminates long-term supercycle behaviour. Nature Communications. Pp 1-9. DOI: https://doi.org/10.1038/s41467-024-53234-0
12. Qinghui Cui, Yuanze Zhou, Yuan Gao, and Ran Cui: Seismic evidence for a thickened mantle transition zone beneath the Kamchatka subduction zone. Earthquake Science 38 (2025) 288–303. DOI: https://doi.org/10.1016/j.eqs.2025.03.001
13. Wu, CF., Rau, RJ. & Chen, YC. Fast report: the (2025) Dapu earthquake: simultaneous rupture of mid-crust antithetic thrust fault linkages in the fold-and-thrust belt of Southwestern Taiwan. *Terr Atmos Ocean Sci* 36, 19 (2025). DOI: https://doi.org/10.1007/s44195-025-00101-0
14. Zixin Chen, Lei Gao, Haijiang Zhang, Shaobo Yang, Ying Liu and Diana Comte. (2025). Intraslab seismicity characteristics of northern Chile. Earthquake Science 38, 273–287. DOI: https://doi.org/10.1016/j.eqs.2025.03.002

AUTHOR'S PROFILE

Mohammed Ali Garba was born in 1978 and hails from Gwoza LGA of Borno State, Nigeria. He attended the Federal University of Technology, Yola, for his first degree in Geology, graduating in 2000. He bagged his M.Sc. degree in Applied Geophysics from the same school in 2010. Also, he earned his PhD in Exploration Geophysics from Prestigious Curtin University of Technology in Perth, Western Australia, in 2018. He began lecturing at Gombe State University in 2010, where he was promoted to the rank of Associate Professor in Geophysics in 2024. Currently, he has 16 International Publications. Also, he is a former level adviser and is now the Departmental Examination Officer of the Department of Geology, Gombe State University. A reviewer of Scientific Journals, amongst which are the Asian Journal of Geographic Research and the Bima Journal of Science. He is also an External Examiner at the Department of Geology in Adamawa State University. He has attended both local and international conferences and is also a member of various university committees and professional bodies, including ASEG, COMEG, NAPE, and NMGS.

Dr. Barka Jonathan, is an Associate Professor of Applied Geophysics at the department of Geology Gombe State University, he is into teaching and research. He holds a B. Tech in Applied Geology from ATBU, Bauchi, and an M.Sc. and a PhD in Applied Geophysics from MAUTech, Yola. His research interests are in the fields of Gravity, Magnetics, Resistivity and Radiometrics. He is married and the union is blessed with two children.

Dr. Edwin Yenika Mbiimbe was born in 1968 and hails from the Northwest Region of Cameroon. He attended Government High School, Kumbo, and obtained GCE O-Level and A-Level certificates (1990). He attended and graduated from the University of Jos, Nigeria, with a B.Sc. degree in Geology and Mining (1995). University of Nigeria, Nsukka: Saw him through with an M.Sc. degree in Hydrogeology (2000). He obtained a PhD in Applied Geology (Hydrogeology& Environmental Hydrogeochemistry) from the University of Maiduguri (2024), Nigeria. He is currently a Senior Lecturer in the Department of Geology at Gombe State University, where he has been a Lecturer since 2007. He is a reviewer for the Bima Journal of Science and Technology & Journal of Applied Physical Science International. He is an external examiner at the Department of Water, Sanitation, and Health at the University of Maiduguri, Nigeria. He is a member of the following professional societies: MNMGS, MNAH, MNAPE, MNAEGE, MIAH, MIMGA, and COMEG Registered.

Dr. Kamureyina Ezekiel holds a PhD in Applied Geophysics (2022) from the Department of Geology at the Federal University of Technology, Yola, Nigeria. Central area of Research: Applied Geophysics. His thesis: Analysis of High Resolution Aeromagnetic and Radiometric Data Over Sokoto Basin and Adjoining Areas, Northwestern, Nigeria. And an M. Sc Applied Geophysics (2007). Department of Geology, Federal University of Technology, Yola, Nigeria. Central area of Research: Applied Geophysics. Dissertation: Analysis of Aeromagnetic Data over Garkida and Environs, Northeastern, Nigeria. Professional Diploma in Education (PDE) (2014), Institute of Education, Ahmadu Bello University, Zaria, Nigeria. NYSC (2002). Department of Works, Shagari Local Government Secretariat, Sokoto State, Nigeria. B. Tech (Hons) Geology (2000). Department of Geology, Federal University of Technology, Yola, Nigeria. Thesis: Aspects of Biostratigraphy and Environment of Deposition of Numanha Shale along Ayatse Stream in Guyuk Sub-Basin of Yola-Arm of the Upper Benue Trough, Northeastern, Nigeria.

Mustafa Ali Garba was born in 1983 and hails from Gwoza LGA in Borno State, Nigeria. He attended Gadamayo Primary School in Gwoza and obtained the First Leaving Certificate in 1985. He then attended Government Day Senior Secondary School, Gwoza, and obtained his SSCE in 1991. He later attended the University of Maiduguri for his First Degree in Physics in 2020. And a Postgraduate Diploma in Physics from Bayero University, Kano, Nigeria, in 2022. He bagged his M.Sc. degree in Physics from the University of Maiduguri in 2024. He started teaching at Government Day Senior Secondary School, Gwoza, in 2021. Currently, he has 2 International Publications.