TOWARDS HARNESSING THE AESTHETIC VALUES OF POTENTIAL MOUNTAINOUS TOURISM SITES IN ONDO STATE, NIGERIA: TERRAIN CHARACTERIZATION AND MAPPING APPROACHES.

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DOI: https://doi.org/10.33281/JTHS20129.2022.2.8

Abstract
Through inadequate planning and tourist inflow management, insufficient knowledge of terrain characteristics and elevation data necessary for terrain mapping raises the hazards of environmental damage and tourist safety in mountainous tourism destinations. This study determined the topographical characteristics and the best digital elevation model (DEM) to extract accurate absolute terrain attributes of four potential mountainous tourism sites in Ondo State, Nigeria (Idanre Hills, IH; Oyemekun Rock, OR; Cave of Ashes, CoA, and Oke-Maria, OM). The extraction, correlation scatter plotting, DEM profiling, and differencing tools, as well as field survey and GIS technology methodologies, were used. In IH, OR, CoA, and OM, there were 34, 15, 1, and 21 tourism attractions/support facilities, respectively. ALOS W3DDSM had the highest mean elevations at the IH (352.95 ± 3.00m), OR (346.36 ± 3.00m), and CoA (360.00 ± 7.37m), whereas SRTM DEM had the highest mean elevation at the OM (496.61 ± 23.51m). The study showed the potential of the sites for high altitude-related recreation activities and the effectiveness of ALOS W3DDSM for terrain characterization. To achieve proper planning, sustainable development, and tourist safety, the ALOS W3DDSM should be incorporated with other critical factors for the tourism zoning of these prospective mountainous regions.
Keywords: Terrain, mountain tourism, Idanre Hills, Oyemekun Rock, Cave of Ashes, Oke-Maria

Introduction
Mountain regions across the world have been attracting local and foreign tourists in recent years in order to capitalize on their tourism potential. These areas offer ecological, economic, recreational, social, educational, and scientific significance that must be managed and promoted sustainably (Glushkova, Zhiyanski, Nedkov, Yaneva and Stoeva, 2020; Mellaku, Melka, Ayenew, Teshale Taye and Tilahun, 2022). Many prospective mountain tourist destinations in developing countries like Nigeria have yet to be properly used for socio-cultural integration, educational advancement, and economic growth. Nigeria is a country with thirty-six states and a federal capital territory that is endowed with abundant biodiversity, natural landscapes, and beautiful mountain scenery (Ajayi and Eveso, 2017). Ondo State is one of the

Nigerian states having many unique resources of international ecological and touristic value. However, these resources, like those of other Nigerian states, are badly packaged and promoted in order to attract and satisfy visitors (Ijeomah and Eniang, 2018).

Based on these and other factors, the state capital (Akure) was chosen in 2020 as one of Nigeria's United Nations Development Project (UNDP) millennium development cities (Aribigbola, 2009; Oladeji and Oladapo 2014). The city's selection was thought to have a good, drastic, and major developmental influence on other Ondo State towns. But, until the current period of Sustainable Development Goals, the city and its surrounding towns are a long way from realizing the distinctive goals of the UNDP millennium development city. Poor planning and management of tourist influxes raise the hazards of environmental degradation and tourist safety in mountainous tourism sites (Zhou and Liu, 2017; Ziegler, Wasson, Sundriyal, Srivastava, Sasges, Ramchunder and Apollo, 2021; Romeo, Russo, Parisi, Notarianni, Manuelli and Carvao, 2021). No research has yet been conducted in Ondo State to characterize the topography of its mountainous landscapes and provide the best digital elevation model for accurate terrain characterization.

Understanding terrain characteristics and elevation data for terrain mapping is critical for appreciating aesthetic qualities, destination management, and long-term development of mountainous tourist sites. Landforms can be described qualitatively and quantitatively using terrain characterization and mapping (Schillaci and Braun, 2015; Piacentini, Troiani, Torre and Menichetti, 2021). Apart from geomorphology, it has been used in many other research fields, including forestry (Azita, Muhammad-Shafeeq, Thinaraj, and Paul, 2019; Hawker, Uhe, Paulo, Sosa, Savage, Sampson, and Neal, 2022), hydrology (Mihaela, Codruța, Gabriel, and Daniela, 2017; Dimple, Rajput, Al-Ansari, Elbeltagi, Zerouali and Santos, 2022), archaeology (Parcak, 2017; Verhagen, 2018), tourism/ecotourism (Farsari and Prastacos, 2004), etc. To design a great and fascinating mountain trip, an appropriate awareness of the landscape, landforms, visitor abilities, and behavior is required in tourism (Tirla, Matei, Cuculici, Vijulie and Manea, 2014). The best path across a mountain area is determined by ground accessibility and tourism goals. As a result, terrain characterization and mapping, which are necessary to describe landform patterns, are critical and have been a continuous concern in recent years in order to avoid risks (Chiou, Tsai and Leung, 2010; Smith, Paron and Griffiths, 2011).

Prior to introducing Digital Elevation Models (DEMs), diverse landforms and their terrains were manually recognized and mapped through ground surveys and interpreting aerial pictures (Garbrecht and Martz, 2000). The Shuttle Radar Topography Mission (SRTM) DEMs were the first global datasets generated by space-borne radar equipment when they were released in 2003. At the time of the first release, the data had 3 arcsec (90m) pixel spacing, with absolute and relative height accuracies of 9m and 10m, respectively (Rodriguez et al., 2006). The global elevation data got from the

Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) was then released for the first time in 2009. It has a 13m height accuracy with 1 arcsec (30m) pixel spacing (Tachikawa et al., 2011). ALOS World 3D is quickly becoming a popular global elevation data source, providing significant contributions to both topographic and non-topographic applications (Tadono et al., 2015).

The stated qualities of ALOS World 3D DSM (global coverage and medium resolution) are immediately appealing to interested users, but its inherent property is frequently disregarded by many data users or has yet to be documented (Santillan and Makinano-Santillan, 2016). Despite the filling of void holes, removal of no data, and greater vertical and horizontal accuracies in elevation data, ALOS World 3D DSM is yet to be accepted in the terrain analysis of mountainous tourism sites. In a hilly tourism site, the absolute accuracy of the ASTER GDEM and ALOS World 3D DSM has not been confirmed by comparing them to the SRTM. According to Amans et al. (2013) and Mesa-Mingorance and Ariza-López (2020), the precision of DEMs affects definite computations and spatial analysis. Several other studies had tested ASTER's accuracy in several locations by employing Ground Control Points (GCP) got by differential GPS or elevations from topographic maps (Rawat et al., 2013; del Rosario Gonzalez-Moradas and Viveen, 2020). Using high-accuracy DEM is highly useful for obtaining the absolute topographical parameters of a tourism location.

There is presently insufficient information on the terrain parameters of potential mountainous tourism destinations in Ondo State for further terrain modeling and tourism planning. Terrain attributes continue to be one of the most key considerations and tools in tourism planning and management (Oprea, Ienciu, Tudorascu and Filip, 2015). Errors in terrain analysis must be assessed in order to provide users with information on the best DEM with a high accuracy of terrain attributes. The SRTM DEM was chosen as a reference surface because of its seamlessness, user-friendliness, and website, which is accompanied by extensive documentation on filling gaps. As a result, this study compared ASTER GDEM and ALOS World 3D to SRTM DEM (the reference surface). It determined topographical characteristics and the best DEM to be used in extracting accurate absolute terrain attributes of tourism attractions and support facilities in Ondo State, Nigeria.

Methodology

Study Area:

The study was conducted in four potential mountainous tourist destinations in Ondo State, Nigeria (Idanre Hills, Idanre; Oyemekun Rocks, Akure; Cave of Ashes, Isharun; and Oke-Maria, Oka-Akoko) (Figure 1). Idanre Hills is a potential World Heritage site in Ondo State, Nigeria, situated in the Idanre Local Government Area. It's between latitudes 6°58'N and 7°07'N, and longitudes 5°01'E and 5°11'E. It is a potential mountain tourism destination that has a tropical climate with an average annual temperature of 26.90

degrees Celsius and an average yearly precipitation of 1,747 millimeters (UNESCO, 2007). The Idanre Hills include around 640 steps with five resting spots and naturally formed steep-sided inselbergs that are smooth and dome-shaped, named after historical figures in the socio-cultural evolution of Idanre land-Olofin, Orosun, Aghagha, Agbogun, Carter, Ajimoba, Ilesun, and others (Adisa, 2010; State Information Technology Agency, 2011; Adeniran, 2012; Itayemi, 2012; Ojo, 2014; Kashim et al., 2015).

Oyemekun Rocks are located in the center of Akure, Nigeria, at latitude 7°15.44'N to 7°15.54'N and longitude 5°10.19'E to 5°10.29'E. Akure is also one of the designated UNDP MDGs cities worldwide (Aribigbola, 2009). Oyemekun rock is a rock outcrop containing various geographic

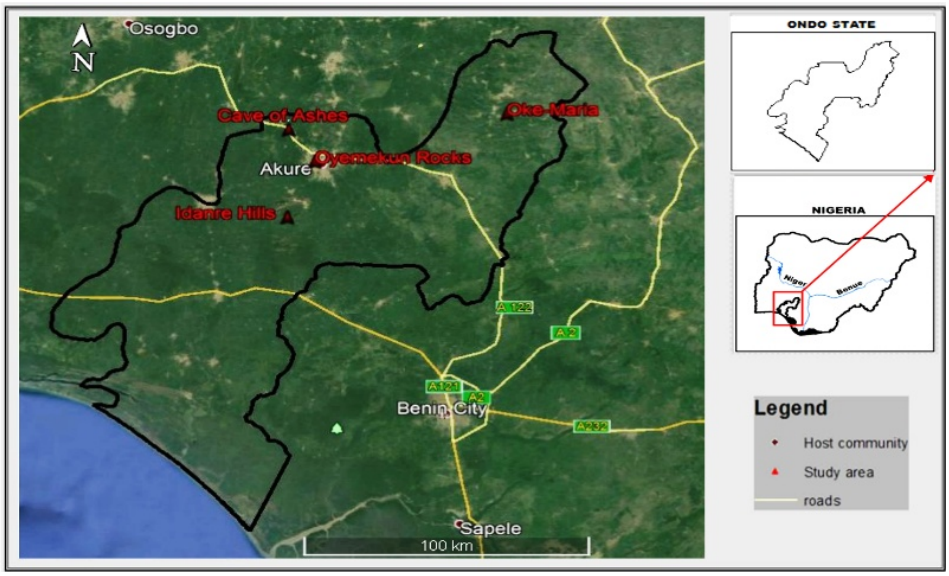

Figure 1: The studied potential mountainous tourism sites in Ondo State, Nigeria

Source: Field Survey, 2019

and historical inscriptions. The tourist site is surrounded by people of many cultures, with the Akure people predominating (a Yoruba cultural sub-group). These people are most known for farming cash and food crops such as cocoa, yams, maize, and cassava, among others.

Cave of Ashes is between latitudes 7°24.54'N and 7°24.96'N, and longitudes 5°4.83'E and 5°5.18'E. The tourism destination is a few kilometers north of Isharun town and 28.90 kilometers from Akure (the state capital). Its vegetation is dominated by semi-closed secondary forest, which are surrounded and mixed with degraded forests, farmlands, open secondary forest, and rocks of varying sizes. The carvings in the cave are thought by the locals to be divination from the Ifa oracle. It is thought to have been home to

the ancestors of the Iloro people, who were known for their pottery-making skills. The average daily temperature is 29°C, with a high humidity level.
Oke-Maria (also known as Virgin Maryhill) is in Oka Akoko, about 113 kilometers from Akure (the state capital). The coordinates are 7°26.72'N to 7°27.03'N and 5°46.71'E to 5°47.01'E. It is home to a shrine dedicated to the Blessed Virgin Mary, a pre-Vatican II Church, a residence going back at least a century, and a mango tree beneath which marriages and masses for the tiny community were held prior to the construction of a permanent worship area (Offiong, 2014). The lovely Virgin Mary statue at the top of the hill was gifted by Dr. Olivomi's family. The hilltop offers beautiful vistas and an ideal location for pilgrims. Rev. Father Cerminath found the location in 1916, and it has drawn Christians of many denominations to this resort center. Every year in the second week of February, these visitors flock to the hill.

Oke-Maria has a mean annual temperature of more than 21°C, an average rainfall of roughly 1,270mm, and quite high humidity. According to Obata and Aigbokhan (2012), its vegetation consists primarily of savanna and scattered forests, with common flora such as *Anacardium occidentale, Alstonia boonei, Annona senegalensis, Rauvolfia vomitoria, Colocasia esculenta, Elaeis guineensis, Kigelia africana, Mangifera indica,* and others. Pottery and agricultural activities (food and cash crops) are the most common occupations among Isharun and Oka-Akoko residents. Yams, maize, and cassava are examples of food crops. These are grown alongside cash crops such as cocoa, coffee, and rubber. The Oka people's secondary occupations include trading, carpentry, bricklaying, and so on.

Data Collection and Analysis

The study locations' digital elevation models (SRTM, ASTER, and ALOS World 3D) were got from the United States Geological Survey archives. They were geometrically corrected, which implies they were translated and projected from WGS84 into local spatial reference systems (Minna Geographic Coordinate System and Minna Datum Universal Transverse Mercator (UTM) zone 31N). The elevation data has the same resolution (30m). Filter applied to all DEMs to eliminate any remaining outliers in the data (Werner, 2001). The coordinates of tourist attractions and their support facilities in the study area were collected using the Global Positioning System (GPS). Using the create random point tool in ArcGIS 10.4 software, random points were generated at each of the study sites (Idanre Hills, 5000; Oyemekun Rocks, 500; Cave of Ashes, and Oke-Maria) based on the associated land cover area (ESRI, 2016). To extract many topographical values to points and graphically illustrate the elevation trend of tourism attractions/support facilities, the Extraction tools (spatial analyst tools) of ArcGIS 10.4 software and Microsoft Excel 2017 were used.

Skewness and kurtosis were calculated for each DEM based on the elevation values associated with the multiple points. The negative and positive skewness can be represented by a long tail to the left and right, respectively.

Excess kurtosis is a unitless measurement of the sharpness of the data peak. A number greater than zero (0) shows a peaked distribution, while less than zero (0) shows a flat distribution (Wilson and Gallant, 2000). The Idanre Hills, Oyemekun Rocks, Cave of Ashes, and Oke-Maria were profiled using 12km, 180m, 750m, and 550m profile lines. Elevation points were collected from the same SRTM, ALOS WORLD, and ASTER DEMS profile line for comparison and correlation of SRTM elevation sample points and profile with other DEMs. The same line of sight was generated for each DEM, exported as a CSV file, and then processed in the ArcGIS 10.4 environment (Wobus et al., 2006).

The magnitude and direction of the relationship between the Digital Elevation Models were analyzed using correlation scatter plots. Making a scatter plot from all the pixels in a DEM is tough, since each DEM has over a million pixels. As a result, the scatter plots are based on randomly selected points/pixels (Tighe et al., 2009). Using the DEM surface tools for ArcGIS 10.4 software, DEM differencing was used to calculate the surface ratio, surface, and flat areas between the reference DEM (SRTM) and other DEMs. According to Jenness (2013), the Surface Ratio is a useful index of topographic roughness and convolutedness in which the surface area values of each cell are divided by the planimetric area of that cell. Surface Area provides a more realistic estimate of accessible land area, with cell values reflecting the topographic surface area inside that cell. If the raster is projected, the flat area is the planimetric area of the cell, with the same value equal to the square of the cell size.

Results

Table 1 shows the topographical characteristics of potential mountainous tourism sites in the Ondo State, Nigeria. The ALOS World 3D DSM had the highest mean elevation (352.95 ± 122.83 m) in Idanre Hills, while the ASTER GDEM had the lowest (337.08 ± 120.02 m). However, the elevation retrieved from the reference (SRTM) DEM exhibited the highest skewness (1.43), as well as the highest kurtosis (2.75). The ASTER GDEM elevation has the lowest skewness (1.30) and kurtosis (1.91). The slope extracted from ASTER GDEM had the highest mean ($12.29^0 \pm 8.70^0$), while the reference (SRTM) slope had the lowest mean slope ($11.84^0 \pm 9.54^0$). The skewness (1.49) and kurtosis (3.12) of the reference (SRTM) DEM were the highest, while the skewness (1.29) and kurtosis (2.08) of the ASTER GDEM were the lowest.

The ALOS World 3D DSM had the highest mean elevation (346.36 ± 0.66 m) in Oyemekun Rocks, while the ASTER GDEM had the lowest (346.16 ± 2.67 m). However, the elevation extracted from the reference (SRTM) DEM exhibited the highest skewness (1.03), and the highest kurtosis (1.38). The elevation extracted from ASTER GDEM exhibited the lowest skewness (0.39), and the lowest kurtosis (-0.76). ASTER GDEM had the highest mean slope ($3.94^0 \pm 1.14^0$), while ALOS World 3D DSM had the lowest mean slope ($0.69^0 \pm 0.17^0$). The reference DEM (SRTM) had the highest skewness (0.68) and

negative kurtosis (-0.82), while the ASTER GDEM had the lowest skewness (-0.73) and negative kurtosis (-0.75).

The ALOS World 3D DSM had the highest mean elevation (360.00 ± 7.37 m) in the Cave of Ashes, while the ASTER GDEM had the lowest (352.65 ± 7.31 m). The elevation extracted from the reference (SRTM) DEM had the highest skewness (0.80) and the lowest kurtosis (311.99). The kurtosis of the elevation extracted from ALOS World 3D DSM was the highest (338.85). The slope extracted from ASTER GDEM had the highest mean ($5.91^0 \pm 3.19^0$), while the slope extracted from ALOS World 3D DSM had the lowest mean ($3.82^0 \pm 1.92^0$). Kurtosis was negative in all the DEMs. ASTER GDEM had the highest skewness (0.14), while ALOS World 3D DSM had the least (0.08). ASTER GDEM had the highest kurtosis (-0.07), while reference (SRTM) DEM had the lowest (-0.45).

The reference (SRTM) DEM had the highest mean elevation (496.61 ± 23.51 m) in Oke-Maria, while the ASTER GDEM had the lowest (485.60 ± 19.59 m). The elevation extracted from the reference (SRTM) DEM had the highest skewness (1.62) and the lowest kurtosis (43.14). The kurtosis of the elevation retrieved from ASTER GDEM was the highest (45.66). The mean slope extracted from the reference (SRTM) DEM was the highest ($14.62^0 \pm 9.01^0$), while the mean slope extracted from ASTER GDEM was the lowest ($12.90^0 \pm 7.51^0$). Kurtosis was negative in all the DEMs. The skewness of the reference (SRTM) DEM was the highest (1.73), while the skewness of the ASTER GDEM was the least (0.08). In addition, the reference (SRTM) DEM had the highest kurtosis (-1.23), while ALOS World 3D DSM had the lowest (-1.29).

Figure 2 depicts elevations of ecotourism attractions and support facilities in potential mountainous tourism sites in Ondo State, Nigeria. In Idanre Hills, thirty-three (33) ecotourism attractions and support facilities were found. For the reference (SRTM) DEM, the communication mask had the greatest height (594.56 m), while the reception building had the lowest elevation (313.89 m) for the ASTER GDEM. In Oyemekun Rocks, fifteen (15) ecotourism attractions and support facilities were identified. The ecotourism attractions and support facilities are at elevations ranging from 328.67 m to 346.11 m. There are no ecotourism support facilities in the Cave of Ashes. There are twenty-one (21) ecotourism attractions and support facilities in Oke-Maria. In all the digital elevation data, Mary's statue has the highest elevation (535.00 m). The reference (SRTM) DEM and ALOS World 3D DSM had the lowest elevation of 499.00 m and 495.00 m for two ecotourism attractions and support facilities (general toilet and water tank 3). For the ASTER GDEM, the first primary school in Oka had the lowest elevation (483.00 m).

Figure 3 shows topographic profile line graphs of digital elevation data across potential mountainous tourism sites in the Ondo State, Nigeria. According to the trend, the ALOS World 3D DSM has the highest elevation among the four potential mountainous tourism sites. Along the profile line, there were also interwoven patterns between the reference (SRTM) DEM and ALOS World 3D DSM. The ASTER GDEM exhibited the least elevation along

all the profile lines. Figure 4 illustrates a scatter plot of elevation values collected from (A) SRTM (Reference DEM) against ALOS WORLD 3D DSM (B) SRTM (Reference DEM) versus ASTER GDEM in potential mountainous tourism sites in Ondo State, Nigeria. In the Idanre Hills ($R^2 = 0.99$), Oyemekun Rocks ($R^2 = 0.68$), Cave of Ashes ($R^2 = 0.97$) and Oke-Maria ($R^2 = 0.99$), the SRTM (Reference DEM) outperformed the ALOS WORLD 3D DSM based on the coefficient of determination. In the Idanre Hills ($R^2 = 0.98$), Oyemekun Rocks ($R^2 = 0.32$), Cave of Ashes ($R^2 = 0.89$) and Oke-Maria ($R^2 = 0.98$), SRTM (Reference DEM) had a lower coefficient of determination than ASTER GDEM. Table 2 shows the results of differencing digital elevation data of potential mountainous tourism sites in the Ondo State, Nigeria. Except for the Reference SRTM DEM at Oke-Maria (1,289.85 m^2), ASTER GDEM has the highest maximum surface area in the Idanre Hills (2,219.43 m^2), Oyemekun Rocks (978.90 m^2), and Cave of Ashes (1,017.53 m^2). In Idanre Hills, ALOS World 3D DSM had the highest maximum surface ratio (6.03) and SRTM DEM had the lowest (1.40). ASTER GDEM had the highest maximum surface ratio (1.06) in the Cave of Ashes, while ALOS World 3D DSM had the lowest maximum surface ratio (1.01). The minimum surface ratio (1.00) and flat area (956.31 m^2) were the same for all digital elevation data. ALOS World 3D DSM has the highest minimum (957.31 m^2) and maximum (1,246.87 m^2) surface area in Oke-Maria. The SRTM DEM (Reference) has the least minimum (957.80 m^2) and maximum (1,289.85 m^2) surface area. In addition, SRTM DEM (Reference) had the highest maximum surface ratio (1.35), while ALOS World 3D DSM had the lowest maximum surface ratio (1.30). The minimum surface ratio (1.00) and flat area were the same for all digital elevation data (956.31 m^2).

Table 1: Topographical characteristics of the potential mountainous tourism sites in the Ondo State, Nigeria

Study sites	Digital Elevation Models/ Topographical characteristics	Minimum	Maximum	Range	Mean	Standard deviation	Skewness	Kurtosis
Idanre Hills	Reference (SRTM)_Elevation	178.14	1062.89	884.75	351.51	122.95	1.43	2.75
	ALOS World 3D_Elevation	179.75	1051.22	871.47	352.95	122.83	1.42	2.67
	ASTER GDEM_Elevation	159.78	907.89	748.11	337.08	120.02	1.30	1.91
	Reference (SRTM)_Slope	0.00	79.01	79.01	11.84	9.54	1.49	3.12
	ALOS World 3D _Slope	0.00	80.41	80.41	11.79	9.48	1.47	3.06
	ASTER GDEM_Slope	0.00	64.40	64.40	12.29	8.70	1.29	2.08
Oyemekun Rocks								
	Reference (SRTM)_Elevation	345.33	347.22	1.89	346.30	0.44	1.03	1.38
	ALOS World 3D_Elevation	345.11	347.67	2.56	346.36	0.66	0.62	0.52
	ASTER GDEM_Elevation	324.00	333.33	9.33	328.16	2.67	0.39	-0.76
	Reference (SRTM)_Slope	0.31	2.45	2.14	1.10	0.67	0.68	-0.82
	ALOS World 3D _Slope	2.31	2.15	1.30	0.69	0.17	0.14	-1.24
	ASTER GDEM_Slope	1.46	5.47	4.01	3.94	1.14	-0.73	-0.75
Cave of Ashes								
	Reference (SRTM)_Elevation	344.00	374.00	31.00	358.44	8.07	0.80	311.99
	ALOS World 3D_Elevation	333.00	376.00	32.00	360.00	7.37	0.78	338.85
	ASTER GDEM_Elevation	333.00	375.00	42.00	352.65	7.31	0.77	329.66
	Reference (SRTM)_Slope	0.00	10.06	10.06	4.22	2.12	0.10	-0.45
	ALOS World 3D_Slope	0.33	9.65	9.32	3.82	1.92	0.08	-0.20
	ASTER GDEM_Slope	0.00	14.49	14.49	5.91	3.19	0.14	-0.07
Oke-Maria								
	Reference (SRTM)_Elevation	425.00	542.00	117.00	496.61	23.51	1.62	43.14
	ALOS World 3D_Elevation	429.00	535.00	106.00	494.63	21.04	1.60	45.09
	ASTER GDEM_Elevation	433.00	519.00	86.00	485.60	19.59	1.56	45.66
	Reference (SRTM)_Slope	0.38	40.64	40.31	14.62	9.01	1.73	-1.23
	ALOS World 3D_Slope	0.98	39.49	38.51	13.16	8.57	1.65	-1.29

	ASTER GDEM_Slope	1.04	39.32	38.28	12.90	7.51	1.64	-1.26

Elevation values were measured in meters, slopes in degrees
Source: Field Survey, 2019.

Table 2: Differencing output of digital elevation data of the potential mountainous tourism sites in the Ondo State, Nigeria

Study areas	Digital Elevation Models	Surface area (square meters)		Surface ratio		Flat area (square meters)
		Mini mum	Maxi mum	Mini mum	Maxi mum	
Idanre hills						
	SRTM DEM (Reference)	956.32	1,340.34	1.00	1.40	956.31
	ASTER GDEM	956.45	2,219.43	1.00	2.32	956.31
	ALOS World 3D	956.33	5,762.46	1.00	6.03	956.31
	ASTER GDEMminusSRTM DEM	0.13	879.09	0.00	0.92	0.00
	ALOS World 3DminusSRTM DEM	0.01	4422.12	0.00	4.63	0.00
Oyemekun Rocks						
	SRTM DEM (Reference)	956.34	959.53	1.00	1.00	956.31
	ASTER GDEM	956.57	978.90	1.00	1.02	956.31
	ALOS World 3D	956.33	959.04	1.00	1.00	956.31
	ASTER GDEMminusSRTM DEM	0.23	19.37	0.00	0.02	0.00
	ALOS World 3DminusSRTM DEM	-.0.01	-0.49	0.00	0.00	0.00
Cave of Ashes						
	SRTM DEM (Reference)	956.93	972.41	1.00	1.02	956.31
	ASTER GDEM	957.31	1,017.53	1.00	1.06	956.31
	ALOS World 3D	956.81	969.09	1.00	1.01	956.31
	ASTER GDEMminusSRTM DEM	0.38	45.12	0.00	0.04	0.00
	ALOS World 3DminusSRTM DEM	-0.12	-3.32	0.00	-0.01	0.00
Oke-Maria						
	SRTM DEM (Reference)	957.80	1,289.85	1.00	1.35	956.31

	ASTER GDEM	958.18	1,256.87	1.00	1.31	956.31
	ALOS World 3D	957.31	1,246.87	1.00	1.30	956.31
	ASTER GDEM minus SRTM DEM	0.38	-32.98	0.00	-0.04	0.00
	ALOS World 3D minus SRTM DEM	-0.49	-42.98	0.00	-0.05	0.00

Source: Field Survey, 2019

Figure 2: Elevation of the ecotourism features and support facilities in the potential mountainous tourism sites of the Ondo State, Nigeria.

Source: Field Survey, 2019

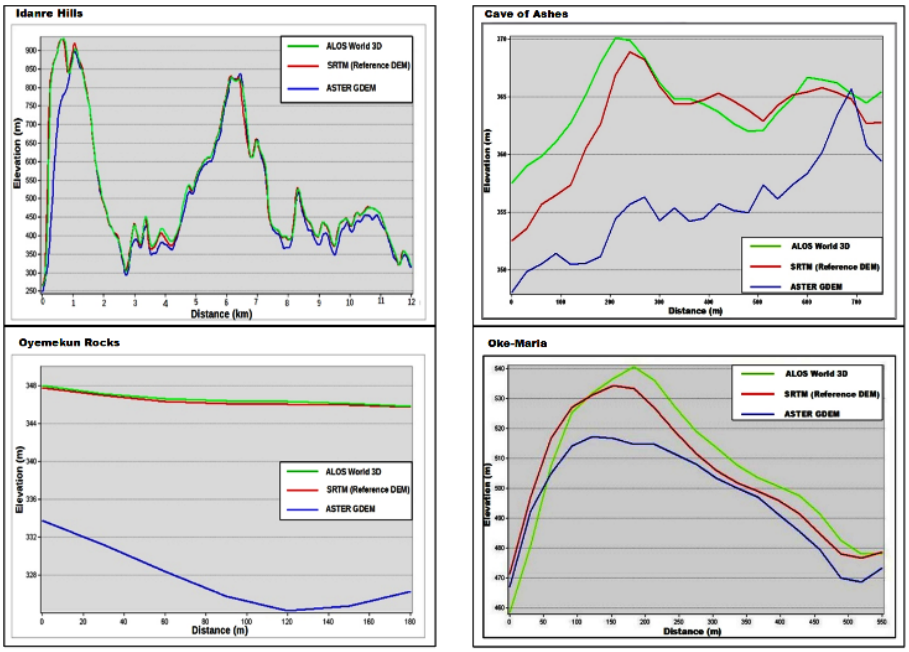

Figure 3: Topographic profile line graphs of digital elevation data over the potential mountainous tourism sites in the Ondo State, Nigeria.

Source: Field Survey, 2019

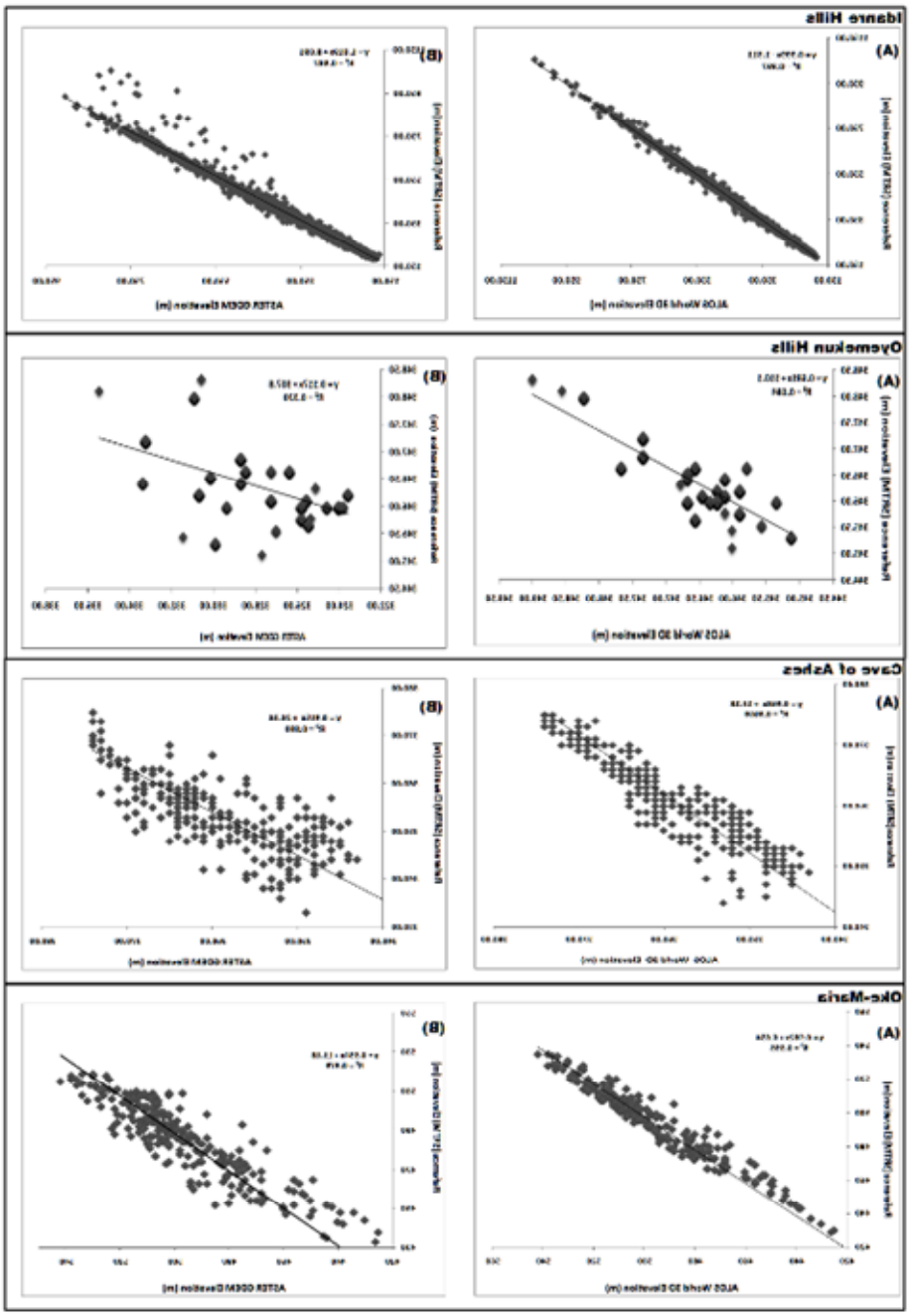

Figure 4: Correlation scatter plot of the elevation values extracted from (A) SRTM (Reference DEM) versus ALOS WORLD 3D DSM (B) SRTM (Reference DEM) versus ASTER GDEM in the potential mountainous tourism sites of the Ondo State, Nigeria
Source: Field Survey, 2019

Discussions

According to Charters and Saxon (2007), the four research sites (Idanre Hills, Oyemekun Rocks, Cave of Ashes, and Oke-Maria) can be considered mountains because they have a height of more than 300m (984 ft). Except for rock climbing, mountain biking, hiking, and trekking, the topographical characteristics (elevation and slope) of the locations showed their considerable potential for high altitude-related recreation activities. According to Nepal and Chipeniuk (2005), mountainous locations with tourist aesthetic characteristics may be divided into three zones depending on elevation: tourism centre, front country, and backcountry. Aside from the Idanre Hills, which have elevation values of a few areas above 1000m, most mountain tourism sites are suited for activities linked with the tourism center and front country zones. Sports and leisure activities, wildlife viewing, nature photography, recreation, culture, camping, and hiking may be available at the destination.

Through toll revenue and increased economic activity, visitors' participation in these activities will produce money for the authorities of potential mountain tourism sites and local communities, which will have a multiplier effect on the local economy. According to Nepal and Chipeniuk (2005), mountains characterized by magnificent landscape and exceptional amenity values are among the most popular tourist destinations, with economic potential. Tourist participation in mountain tourist sites in a few countries, including Sweden, India, Nepal, Nigeria, and Tajikistan, boosted local communities' livelihoods and foreign exchange (Khadka and Jalilova, 2013; Kelliher, 2014; Aswani et al., 2015; Devkota et al., 2016; Diminyi and Okpoko, 2019; Onyeabor and Nwahia, 2020; McGrath, 2022). The terrain characteristics of the four locations showed their appropriateness and suitability for mountain tourist growth, particularly in terms of tourism safety.

Because of the fast expansion of the tourist business, tourism safety has recently become a topic of discussion. Several writers had concentrated on developing a framework to comprehend the aspects and ways to be addressed in tourist safety risk management (Roe et al., 2014; Zhou and Liu, 2017; Feng et al., 2022). The delicate, rocky, and difficult topography of most mountain landscapes in Idanre Hills made up a major constraint. However, with more research on mountain tourist zoning in the Idanre Hills, the risks connected with high-altitude mountain activities can be reduced. Because of their favourable slopes, the Oyemekun Rocks, Cave of Ashes, and Oke-Maria have the terrain, historical, and cultural advantages to exploit their environmental and economic potential. Despite their geographical advantages, the three locations are still a long way from realizing their full potential. The Cave of Ashes, in particular, is now dealing with inadequate destination management, low infrastructure development, land use conflict with agricultural activities, and low marketing, among other issues.

This study confirmed the vertical accuracy of ALOS World 3D DSM based on the findings of the absolute terrain characteristics, correlation scatters

plotting, DEM profiling, and differencing of the potential mountainous tourism sites in Ondo State. Takaku et al. (2014) reported that the ALOS World 3D DSM generated by the Panchromatic Remote-sensing Instrument for Stereo Mapping has a high vertical resolution (5 m root-mean-square). However, the deviations between the SRTM DEM (reference) and the other DEMs were insignificant and followed indefinite/interwoven patterns. ALOS World 3D DSM outperformed in extracting the topography characteristics of most tourist sites and their associated services. On the rugged Northeastern Mindanao, Philippines, our findings agree with Santillan and Makinano-Santillan (2016) that ALOS World 3D DSM has greater vertical accuracy and is a workable alternative to existing global DEMs such as SRTM DEM 30m and ASTER GDEM. In contrast to the DEM differencing (surface area and ratio) used in this work, the authors' conclusions were mostly based on the concept of root-mean-square error and the coefficient of determination.

Conclusion

This study revealed the potential of the mountainous tourism sites in Ondo State, Nigeria. Compared to Oyemekun Rock and Cave of Ashes, Idanre Hills had more tourism attractions/support facilities, followed by Oke-Maria. It is observed that the tourist attractions and support facilities of the potential mountainous destinations are insufficient and yet to be well developed. The four tourism destinations have great potential for mountain-related recreation activities such as sports and relaxation, wildlife viewing, nature photography, recreation, culture, camping, hiking, and to improve host communities' economic livelihood. Also validated was the accuracy and efficiency of ALOS World 3D DSM for terrain characterization and mapping of a mountainous tourist destination, and the terrain data provides a better alternative to the widely used SRTM DEM in terrain mapping. Therefore, it is recommended that the major stakeholders such as host communities, Ondo State Catholic Diocese (for Oke-Maria), government and private organizations, etc to the four sites should exert and harmonize their efforts. Concerted efforts and further researches are expedient to integrate the ALOS W3DDSM with other essential factors for the tourism zoning of each of the potential mountainous destinations to ensure their adequate planning, sustainable development, and tourist safety.

Acknowledgements

Our grateful appreciation goes to the Ondo State Ministry of Culture and Tourism, as well as the authorities of Idanre Hills, Oyemekun Rocks, Cave of Ashes, and Oke-Maria, for their permission, warm reception, and invaluable help during data collecting. The useful collaboration of Isharun town's traditional council members is much appreciated. In addition, we are grateful for the intellectual platform offered by the Center for Diverse Leadership in Science, Institute of the Environment and Sustainability,

University of California, USA, through the Early Career Fellowship awarded to the first and corresponding author.

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