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Landform Classification for Site Evaluation and Forest Planning: Integration between Scientific Approach and Traditional Concept

(Pengelasan Bentuk Muka Bumi bagi Tujuan Penilaian Kawasan dan Perancangan Hutan: Integrasi antara Pendekatan Sains dan Konsep Tradisi)

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ABSTRACT

In this paper, we present an automated classification method of landform elements using an application of SAGA GIS software. The spatial assessment was done on the Yambaru forest area (YFA) in the northernmost part of Okinawa Island, Japan. This task is performed through the detailed elevation grid analyses from DTM of YFA with a spatial scale of 10 × 10 m² supported by The Geospatial Information Authority of Japan. The classification has ten classes; high ridges, midslope ridges, upland drainage, upper slopes, open slopes, plains, valleys, local ridges, midslope drainage and streams. Classes were defined using the 'topographical position index' module and selected terrain variables were integrated to vegetation data for site evaluation. Information on terrain characteristics is very important to explain geographical constraints and map variability of natural resources in maintaining sustainable forest management as well as supporting decision making processes. Taking this into account, we adapted a traditional concept of forest terrain introduced by Sai On, a council member of the Ryukyu Kingdom (former name of Okinawa Island) when evaluating the potential site for forestry use.

Keywords: Automated; DTM; landform; Okinawa Island; SAGA

ABSTRAK

Dalam makalah ini, kami membentangkan kaedah pengelasan kawasan dan unsur bentuk muka bumi dengan menggunakan aplikasi perisian SAGA GIS. Penilaian reruang telah dijalankan ke atas kawasan hutan Yambaru, yang terletak di bahagian utara Pulau Okinawa, Jepun. Tugasan ini dijalankan melalui analisis terperinci grid ketinggian muka bumi (DTM) dengan skala 10 × 10 m², yang disediakan oleh Lembaga Penyebaran Maklumat Geospatial Jepun. Bentuk muka bumi telah dibahagikan kepada sepuluh kelas. Maklumat mengenai ciri bentuk muka bumi sesebuah kawasan adalah sangat penting bagi menerangkan kekangan geografi yang wujud dan untuk pemetaan kepelbagaian sumber semula jadi; sebagai salah satu langkah untuk mengekalkan pengurusan hutan mapan selain menyokong proses pembuatan keputusan oleh pihak berwajib. Dalam kajian ini, kami turut mengadaptasi konsep tradisi pengelasan kawasan hutan yang telah diperkenalkan oleh Sai On, iaitu seorang ahli majlis di kepulauan (nama asal bagi Pulau Okinawa).

Kata kunci: Automatis; bentuk muka bumi; DTM; Pulau Okinawa; SAGA

INTRODUCTION

Topography heterogeneity on a local scale plays an important role in forest management, productivity and diversity (Kubota et al. 2004). Terrain and landform analysis along with additional information, such as surface geology and soil data, will help in understanding the topography of the region and determine the most appropriate sites for various land uses. Better understanding of the process is a key point to conduct forest planning and to achieve successful forest management. The application of the digital terrain model (DTM) in geosciences was introduced in the 1950s (Miller & Laflamme 1958). Many studies were carried out to map the variability of natural resources and landform classification to assess land capabilities. Historically, Dikau (1989) had previously introduced an approach to identify plateaux, convex scarps, valleys and crests; Gardner et al. (1990) developed methods to extract terrain features while Azanon et al. (2001), Bailey (1987) and Cheng et al. (2005), proposed an approach to delineate land into ecosystem units using topographical parameters and cluster analysis. Other significant studies were done by Dragut and Blaschke (2006), who applied object-based image analysis in landform classification and Manap et al. (2010) who had extensively applied the capability of remote sensing in identifying terrain features. Topographical variables and DTM are easily observable features, have high accuracy, are relatively stable in the landscape and therefore are very effective for land classification especially for site evaluation and forest planning (Fabian 2004; Yanni 1996). Many of these classifications, however, require detail steps and extraction of various primary terrains attributes as inputs to classification processes. Comparatively speaking, SAGA GIS software (System for Automated Geoscientific Analysis), which was developed by a team of geospatialists at the Department of Physical Geography, University of Gottingen, Germany, facilitates faster geomorphometrical calculations and terrain computations. This particular software has been designed for easy and effective implementation of spatial algorithms.

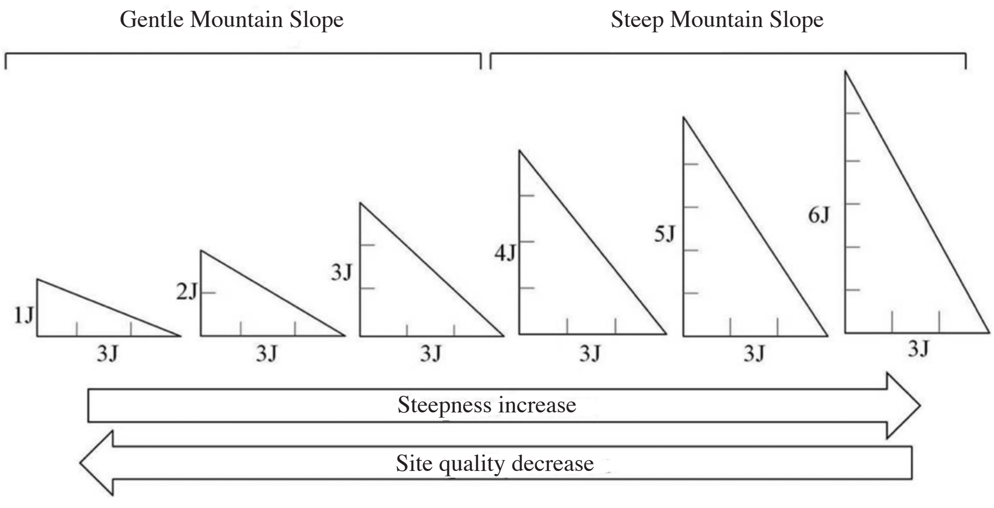
In this study, the application of SAGA GIS was tested on a small watershed in the Yambaru forest area (YFA) on Okinawa Island. In YFA, dense subtropical forest starts as near as 10 m from the coastline where the highest elevation is only 503 m. Receiving monsoonal typhoons and strong winds directly from the coast side places the threatened area under complex and severe forest conditions. Detailed analysis on terrain characteristics of the surrounding area is very important to map the land variability and predict topographical constraints for further forest evaluation. However, endangered and poisonous species that inhabit the island have limited accessibility for forest managers to monitor the area directly, which is one of the pertinent challenges in managing the mountainous forest. To overcome this issue, terrain analysis and modelling work are the best way to give insight into forest resources and condition to the managers.

CONCEPT OF TERRAIN ANALYSIS AND SUSTAINABLE FOREST MANAGEMENT INTRODUCED BY SAI-ON IN 'SANRIN SHINPI' - THE SECRET OF FORESTRY

Back in 1751 in the political history of Okinawa Island (formerly known as Ryukyu Kingdom), Sai On, who is a member of the state council, introduced a 'Theory of Forest Terrain,' which emphasized that terrain characteristics should be the primary factor in choosing a location to use especially for forestry and agriculture purposes. Sai On had previously conducted a thorough study of forest growth and methods of forest land use planning, which were documented in several phases (Kerr 2000). The concept introduced was influenced by the natural environment of the island and the requirement of managing the forest area against seasonal wind and/or strong typhoons. The book produced, *Sanrin Shinpi,* emphasized that there are four key points to be considered in forest management and planning: terrain characteristics; a geomorphic concept of embraced protection; the management of timber and the appearance of a forest (Purves et al. 2009). In the document, land characteristics were divided into few levels and described comparatively regarding the functions of each level with the influence of 'feng-shui' (Figure 1). Holding on to the earlier concept of terrain analysis documented in *Sanrin Shinpi*, spatial evaluations and calculations on the landform elements and values were done using multiple applications of GIS.

STUDY AREA

The assessment was done on a small watershed in the Yambaru forest area (YFA), located in the northernmost part of Okinawa Island in Southern Japan (Figure 2). This region covers 10.75 km^2 of YFA and has a highly diversified georelief. The mean monthly temperature is between 12 and 30°C, and the mean daily temperatures in the warmest month (July) and the coldest month (January) are 28 and 16°C, respectively. Precipitation ranges from 1900 to 4000 mm/year with the mean value of 2745 mm (Japan Meteorological Agency; retrieved on March 2012). Summers are hot and humid while winters are warm and dry. The subtropical forest of Yambaru has high species richness (Ito 2003) and receives frequent typhoons and monsoonal winds. The bedrock is composed mainly of tertiary sandstone, palaeozonic clay–state and a red yellow forest soil (Kojima 1980). YFA is dominated by subtropical evergreen broadleaf trees, especially *Castanopsis sieboldeil* (local name: Itaji), which extend almost to the coastlines.



Remark: Traditional measurement unit (J) = Jo (丈), where 1J = 3.03 m

FIGURE 1. Traditional terrain classification illustrated by Sai On in Sanrin Shinpi: The Theory of Forest Terrain

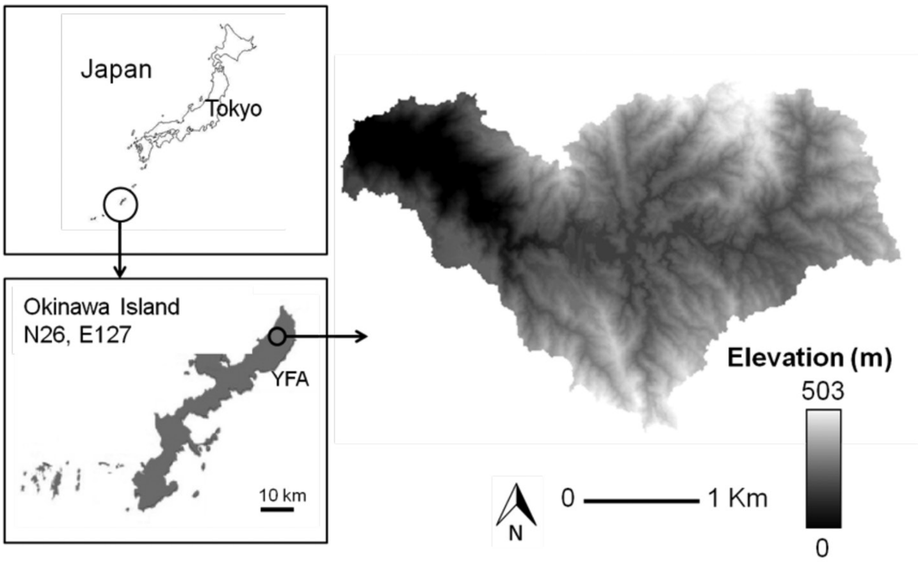


FIGURE 2. Location of Okinawa Island and the study site, Yambaru forest area (YFA) illustrated by elevation map

MATERIALS AND METHODS

Throughout the assessment, we comprehensively used: interpretation of terrain and landform maps derived from the DTM, interpretation of the IKONOS satellite image for land cover assessment and interpretation of remote sensing data of vegetation height (resolution at 1 m). All data layers were then incorporated and zonal statistic analysis was done to describe the quantitative relationship between the variables. Site evaluation was done with respect to comprehensive literature reviews from modern studies as well as traditional concepts by Sai On.

DATA PROCESSING AND ANALYSIS

The study used DTM of YFA with a spatial scale of 10 × 10 m supported by the Geospatial Information Authority of Japan. According to Hutchinson and Gallant (2000), DEM/DTM with a resolution of 5 m to 50 m was defined as fine scale, which was suitable for various analyses including for soil, hydrological modelling and terrain analysis. Terrain analysis and computation was divided into two main sections: the computation of secondary terrain attributes that characterized the landform and automated landform classification for the whole watershed area. SAGA GIS software was effectively used in this process.

THE COMPUTATION OF SECONDARY TERRAIN ATTRIBUTES

The first step was conducted by an automated derivation of primary terrain attributes which are slope, aspect and catchment area. These parameters which were previously studied to have significant influence on hydrological processes and landform development were simulated using numerical expressions to produce secondary terrain attributes namely topographic wetness index (TWI) and terrain ruggedness index (TRI). Each of these attributes was selected as their algorithms differentiate grid cells that are related to soil-forming process. The terrain indices were expressed as:

$$\text{Topographic wetness index, TWI} = \text{In}\ (A_s / \tan \beta),$$

where A_s is the Catchment area (m^2/m) and β is the slope in degree. The formula was taken after Wilson and Gallant (2000). TWI was constructed by considering two shapes of slope; concave and convex. Concave slope in low gradient areas will gather water and have low TWI while convex slope in steep area will shed water and contribute to higher TWI value.

$$\text{Terrain ruggedness index, TRI} = \frac{(\text{TNC} \times \text{TNF})}{(\text{TNC+TNF})},$$

where TNC is the total number of contour intercepts along the transect and TNF is the total number of fluctuations. TRI calculation was done following a formula introduced by Nellemann and Thomsen (1994). This formula incorporated the effects of slope and terrain undulations, where area with many contour intercepts, will produce high value and steep but smoother terrain will have low values (Nellemann & Gareth 1995).

LANDFORM CLASSIFICATION TECHNIQUE: TOPOGRAPHIC POSITION INDEX

The analysis was performed trough the simulation of DTM to obtain topographic position index (TPI) in morphometry module within SAGA GIS. The process calculate the difference between elevation at a specific cell and the average elevation in a neighbourhood surrounding (Tagil & Jenness 2008); describing higher and lower areas which classify the landscape into different morphological classes (Jenness 2005). Unsupervised classification process was done to the DTM following Jenness (2006) and Weiss (2011). The simulation required setting the radius of neighbourhood and its geometric shape based on two different scales or two sizes of radius (Barka et al. 2011). In this study, a radius between 50 m and 1000 m was applied to determine the slope positions. Gaussian and exponential weighting with bandwidth value of 75 was used. The process generated 10 classes of landform features. Zonal statistic and correlation analysis were done to evaluate the relationship between each landform type and selected terrain attributes.

FOREST COVERS CLASSIFICATION USING NDVI ANALYSIS

For vegetation evaluation, two types of maps, satellite image and tree height were used, provided by the Department of Agriculture, Forestry and Fisheries, Okinawa. Normalised difference vegetation index (NDVI) analysis was done on a multispectral image from an IKONOS-2 satellite acquired on 6 February 2007, datum WGS84, with high resolution imagery at 4 m and 1% cloud cover. The image was octhorectified by the JSI (Japan Space Imaging). NDVI was calculated using the formula, NDVI = (NIR – Red) / (NIR + Red), where the values varied between -1 to +1. Low NDVI value reflects sparse or unhealthy vegetation, while higher value represents greener plants (Table 1). Tree height value was calculated by subtractions of the digital terrain model (DTM) from the digital surface model (DSM) derived from remotely sensed LiDAR data at a resolution of 1 m. The data were collected in April 2011 using ALTM 3100 CASI-3, with flight altitude at 1100 m. The scan frequency was 39 Hz and scan angle was ±20°. The data were collected with a small footprint of 0.2 mrad and laser wavelength of 1064 nm. The tree height map obtained was reclassified into seven classes to differentiate its effect on topography. Vegetation cover is an important factor as it has a strong relation to root strength that represents site quality and land use suitability.

TABLE 1. Characteristics of NDVI signatures

NDVI	Dominant cover
-1.0 ≤ 0	Water, pond and streams
0.1 to 0.2	Bare areas, soil and rock
0.2 to 0.3	Shrubs, grassland, agriculture areas and dry forests
0.3 to 0.6	Dense vegetation
≥0.7 to +1.0	Very dense vegetation and tropical rainforest

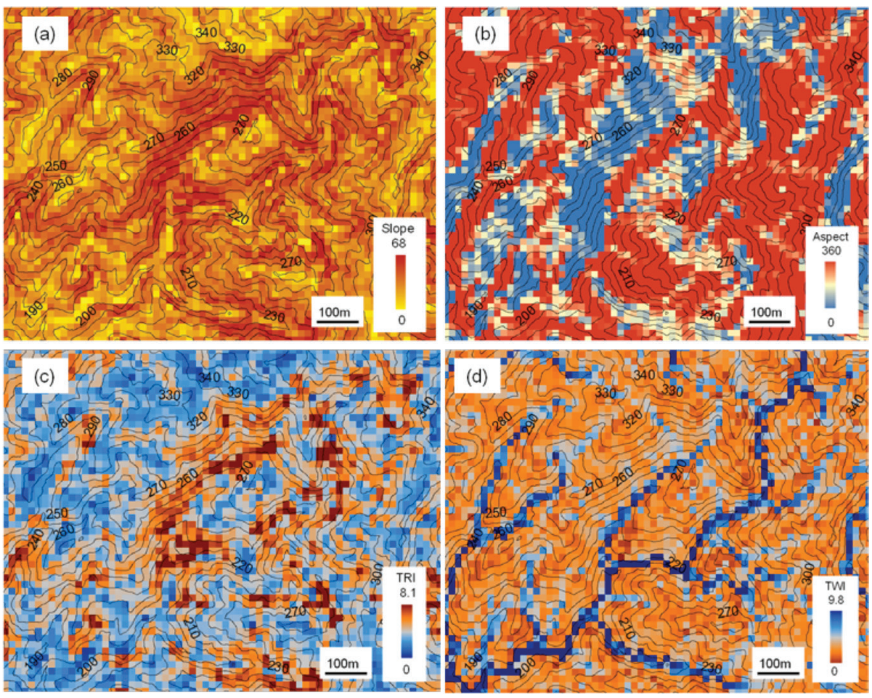


FIGURE 3. Major terrain variables characterized in the landform classes (a) slope (b) aspect (c) terrain ruggedness index (TRI) and (d) topographic wetness index (TWI). Contour distance was set at 10 m

RESULTS

LANDFORM CHARACTERISTICS AND DESCRIPTIONS

Major terrain variables characterized in the landform classes are presented in Figure 3. The image shows the relationship between each variable and terrain steepness where slope, TRI and TWI changes as the terrain become steeper and complex. All these terrain factors are very important in understanding the topographical condition of the study site. The study area was classified into ten different landform types: high ridges, midslope ridges, upland drainage, upper slopes, open slopes, plains, valleys, local ridges, midslope drainage and streams, respectively (Figures 4 & 5). Different colours and patterns on the map denote significant landform features and describe the geographic location of major landforms. Quantitative data are summarized in Table 2. The study site is formed from flat to rugged terrains and gently sloping to hilly areas. Lower elevations concentrated near streams and valleys, having slope categories ranging from 0 to 68° and dense forest area starts from a distance of 5 to 10 m above sea level. High ridges cover 4.82% of the examined area with a mean elevation of 292.15±64.33 m. Slope level in high ridges was considered moderate to steep with a mean value of 21.77±9.74° but a low of TWI of 3.20±0.81. Midslope ridges and upland drainage each cover 10.48 and 0.64% of the total area with slope values of 20.75±8.74° and 29.22±10.88°, respectively and a low TWI of 3.23±0.75 and 3.24±0.92, respectively. TRI values for all types of ridges are at moderate levels. Upper slopes and open slopes cover 12.36 and 46.56% of the total area, with a mean elevation of 272.29±72.53 m and 233.67±49.17 m, respectively. Slope value varies from 19.48±10.88° and 25.21±9.74° with higher exposure of aspect but moderate values of TWI and

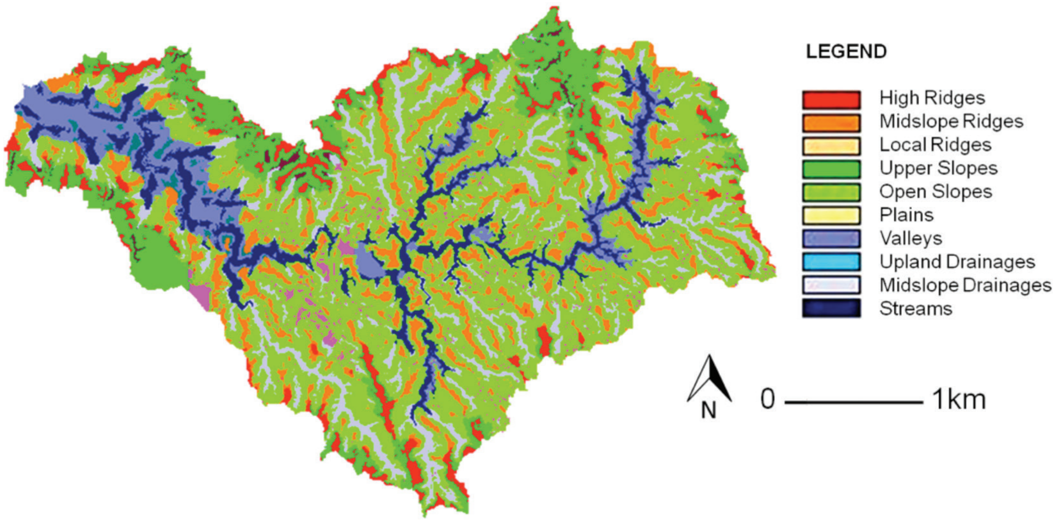


FIGURE 4. Map of landform elements derived from TPI classification analysis

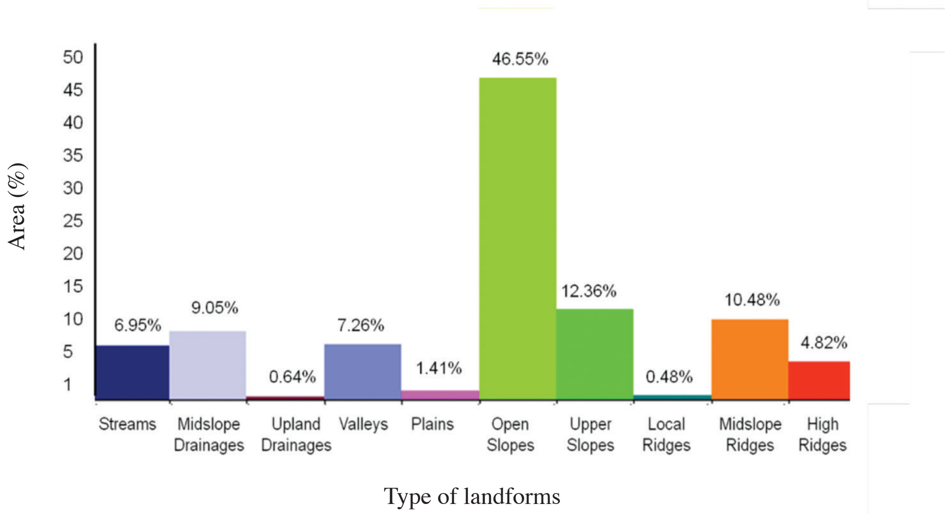


FIGURE 5. Histogram of landform elements

TABLE 2. Zonal statistic shows mean values and standard deviations of major terrain attributes within the zones of landform classes

Landform type	Area (km^2)	Area (%)	Elevation (m)	Slope (degree)	Aspect (degree)	TWI (degree)	TRI (m)
High ridges	0.52	4.82	292.15±64.33	21.77±9.74	172.46±98.54	3.20±0.81	3.56±1.50
Midslope ridges	1.12	10.48	230.34± 51.36	20.75±8.74	181.05±104.85	3.23±0.75	3.59±1.62
Upland drainage	0.06	0.64	78.93±33.48	29.22±10.88	192.51±108.86	3.24±0.92	4.93±2.36
Upper slopes	1.32	12.36	272.29±72.53	19.48±10.88	194.23±99.12	4.54±1.90	3.28±1.73
Open slopes	5.01	46.55	233.67±49.17	25.21±9.74	188.50±104.27	4.12±1.49	4.12±1.78
Plains	0.15	1.41	221.39±35.45	2.29±1.71	173.66±115.16	7.99±3.56	1.07±1.22
Valleys	0.77	7.26	108.63±78.54	24.63±15.46	201.68±101.98	7.99±3.56	4.27±2.73
Local ridges	0.05	0.48	257.26±70.51	24.06±10.88	197.67±90.52	6.79±2.52	4.68±2.04
MS drainage	0.97	9.05	227.28±51.10	26.35±12.03	181.62±103.70	6.71±2.84	4.84±2.19
Streams	0.78	6.95	132.41±69.86	23.49±15.46	191.94±104.27	7.93±4.47	4.68±3.14

TWI: Topographic wetness index TRI: Terrain ruggedness index MS drainage: Midslope drainage

TRI. In this slope position, the area receives higher exposure to wind effects and solar radiation, which produces a lower wetness index value. As explained in an earlier study, a TWI value below 6 is categorized as a dry site with divergent landforms (ridges and upper slopes). A TWI above 7.5 could be dry or wet sites with convergent landforms (lower slopes/flats and depressions), depending on rainfall and evaporation (McKenzie et al. 2000). Plain surface covers only 1.41% of the total area with a mean elevation of 221.39±35.45 m, very low slope of 2.29±1.71°, high aspect value of 173.66±115.16°, low TRI at 1.07±1.22 m but shows high TWI variance at 7.99±3.56. Once again, this result might change depending on rainfall and evaporation. Of the total area, valleys cover 7.26% with a mean elevation of 108.63±78.54 m. Moderate slope, aspect and TRI describe the mentioned sites. The TWI value is 5.38±3.80 shows moderate to high level of wetness index. Local ridge and midslope drainage cover 0.48 and 9.05% of the area with a mean elevation of 257.26±70.51 and 227.28±51.10 m, respectively. Both of these landform elements have high values of TWI at 6.79±2.52 and 6.71±2.84, respectively, as well as high values of TRI at 4.68±2.04 and 4.84±2.19 m, respectively. Streams were found concentrated at a moderate mean elevation of 132.41±69.86 m and a mean slope of 23.49±15.46°. Slope and aspect or solar radiation shows a wide range with the value of 23.49±15.46° and 191.94±104.27°, respectively. The area, however, has a very high variance of TWI and TRI, each at 7.93±4.47 and 4.68±3.14 m, respectively.

The result of correlation analysis is presented in Table 3. The result indicated that TWI factor has a very strong correlation with landform classes with a correlation value of 86% while TRI is significantly correlated to slope factor with a correlation value of 96%. The analysis indicated low values of TWI in high ridges and upper slopes where those areas receive higher wind exposure and compacted soils. Other factors (elevation, slope and aspect) interrelated to each other with moderate *r* value. The correlation values showed that there is an existing dynamic relationship between each variables analyzed. The results suggested that TWI factor could be a very good indicator for site evaluation and forest planning, as well as considering slope level and TRI.

VEGETATION DISTRIBUTION FROM NDVI ANALYSIS AND TREE HEIGHT MAP

The normalised difference vegetation index (NDVI) gives a measure of the vegetation cover on the land surface, differentiating vigorous from less vigorous vegetation. From the analysis, NDVI values for the study site ranges

TABLE 3. Correlation values show relationship between landform class and terrain variables analyzed in the study

Variable	Landform class	Elevation	Slope	Aspect	TWI	TRI
Landform class	1	0.27	-0.05	0.39	-0.86*	-0.28
Elevation		1	-0.31	-0.48	-0.26	-0.37
Slope			1	0.52	-0.33	0.96*
Aspect				1	0.25	0.57
TWI					1	-0.12
TRI						1

*correlation is significant at $p < 0.05$

between -1 and 0.77. We found that NDVI decreases with elevation and has a strong influence on slope position. Higher NDVI value (more than 0.40) was detected concentrated near valleys and streams, where tree height is higher (more than 14 m). Flat areas and high ridges have lower NDVI ranging from 0.2 to 0.3, covering lower tree height (below 8 m). The NDVI of 0.1, which represents rock, soil and bare areas found near upper slope, open slope and midslope drainage. The interpretation of tree height and landform type shows similar results (Figure 6). The differences of NDVI values and dynamic tree height could be explained by several factors. Besides having an influence from agricultural use, we have observed canopy opening in some areas as a result of wind effects in open slopes and flat areas, upward to the forested area in higher ridges.

Discussion

TPI and landform pattern contribute a major impact on soils by controlling water and sediment movement. Within the landform shape and structure, lie a very complex terrain features and characteristics. Elevation, slope and aspect have been demonstrated to be beneficial predictors for the temporal and spatial distributions of variables such as precipitation and radiation; which highly influence vegetation growth and composition (Stage & Salas 2007). Topographic wetness index (TWI) is an index which is widely used to explain water level, sediment content and soil moisture of the area. This index is very important, as it describes soil quality and potential land suitability of certain areas (Wilson & Gallant 2000) (Table 4). TRI or terrain ruggedness index is a measurement to express the amount of elevation difference between cells in digital elevation grid (Riley et al. 1999). TRI explains surface ruggedness or roughness which is a very important variable in selecting an area for development and re-plantation. Alternatively, aspect could be used to explain solar radiation or topographical exposure, described by the symbol 'θ', where in complex terrain, θ is not distributed normally (Hauser et al. 1994; Mikita & Klimanek 2010). In YFA, the topographical index produced an average value between 42° and 60° and shows that the most exposed areas are open areas with mild slopes, plateaus and mountain ridge and the least exposed are deep valleys with steep slopes. Open areas with moderate slopes have low values of TWI while protected area with dynamic slopes and terrain roughness are described with higher values.

On Okinawa Island, mountains are formed near the coast and the coast facing slopes receives more rain that comes from the humid sea air. The opposite slope receives shadow rain, slower winds and the climate is drier. There is often a strong relationship between landform, slope position and soil types which influence the flow of surface water, sedimentation process, wind exposure and solar radiation, hence affecting the quality and distributions of biodiversity (Blaszczynski 1997). For example, high ridge, plateaus and steep slopes are frequently covered with shallow and light sandy soils whereas valleys and midslope drainage often consist of deep and rich alluvial soils. As mentioned by Sai On (1768), flat terrain and gentle slopes are considered to be at the lowest grade for forest growth, where wind exposure is high, there is no barrier of protection and the area has a high potential for damaging typhoon effects. In this study, this situation was explained by lower NDVI values and low tree heights, as well as low TWI near the mentioned zone. The best locations for afforestation are areas with gentle to moderate slopes,

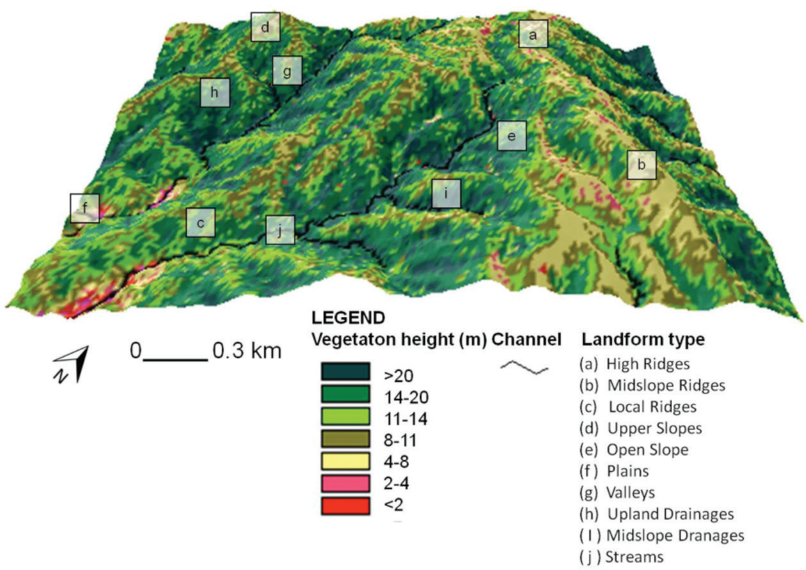


FIGURE 6. Three dimensional (3D) view of tree height map overlayed with landform map explain the relationship between landform type and tree height

TABLE 4. Description of landform classification and proposed forest functions discussed in the study, providing references from Sai On (1768), Arnot and Grant (1981) and Kohler and Breu (2005)

Landform elements	Slope level	Propose land use
High ridge, Upland drainage	Extreme slopes	Protection, conservation, ecotourism and education
Lower ridge, Midslope drainage	Moderate to strong slope	Agroforestry and commercial forest
Midslope Ridge	Moderate slope	Timber harvesting (with strict conservation measures)
Upper slope, Open slope	Moderate to strong slope	Agroforestry, protection and education
Plain, Plateaus	Flat areas to gentle slope	Lowland farming, agriculture and plantation
Valleys	Moderate to low slope	Agroforestry, commercial forest and ecotourism
Stream	Moderate to low slope	Agroforestry, commercial forest and conservation

where the surrounding mountains serve to protect and enclose the area from wind exposure, paralleling with Sai On's concept of 'embrace protection'. As reviewed by Purves et al. (2009) in the English translation of *Sanrin Shinpi*, it is stated that despite soil quality, terrain attributes are the primary factor for successful forest growth. Sai On's observations were strongly influenced by the natural environments of tropical islands, which are highly impacted by strong seasonal monsoon winds and annual typhoons. Understanding landform characteristics such as wetness index, terrain ruggedness and topographic exposure is important, as it provides beneficial information for effective land management and erosion control processes.

Areas receiving higher exposure to solar and wind are very sensitive, where soil fertility and capacity are reduced to hold the vegetation. Development on these areas should be restricted, as it could cause soil erosion, thus increasing the surface runoff, which could make these slopes prone to landslides. This will indirectly affect the coastal zone and will significantly damage the lower vegetation and influence the aesthetic values. However, this issue could be controlled by planting wind resistance trees along the sensitive sites. A study by Duryea and Kampf (2007) recommended a list of proven wind resistant tree species for tropical and subtropical forest types. In the case of Okinawa Island, *Garcinia subelliptica* (Common name: Fukugi) was proven to have high adaptability, capability and strong wind resistance, and it was planted as landscape trees as well as to serve as a wind protection barrier especially in traditional villages and along the lower coastal zone (Chen & Nakama 2001).

Landform and terrain characteristics strongly influence forest health and vegetation pattern. The statement was strongly emphasized in both studies, previously by Sai On's observation and currently by geospatial evaluation. It is agreeable that independent results obtained from digital terrain analysis are not sufficient enough for site evaluation and land use planning. Additional information on abiotic environment (i.e., soil type, geology and forest cover) of the specific study area is required for a concrete and precise land assessment. The application of geostatistical techniques within SAGA GIS provides comprehensive, multifunctional and user-friendly modules that are very effective for geoscientific analysis and DTM computation especially for large regions (Conrad 2006). Supported data from satellite images or remote sensing will improve the evaluation, but the lack of environmental information may be supported through predictive terrain modelling in geospatial applications (Bocco et al. 2001; Thwaites 1995). Terrain analysis and classification based on DTM is very cost effective and time saving, as it provides basic but important information for rational land use especially for developing countries that are under severe environmental and economic constraints.

CONCLUSION

The landform classes obtained from the analysis differentiate dynamic terrain characteristics in the Yambaru forest area. Landform classifications using DTM and GIS are fast, feasible and very user friendly, key attributes in assessing land characteristics, especially for a large region. The presented results and discussion integrated the geospatial approach and a traditional concept of forest terrain. The paper provides an interesting outlook of historical concepts and its re-interpretation using scientific method. By deep understanding of the terrain characteristics, potential and specific constraints of the forest could be detected. Information and methods discussed in this paper will be valuable for landscape and suitability studies especially at regional level.

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