Customization of contour lines generated with conditional parameters using Python.

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Abstract: *Topographic maps are essential in fields such as engineering, agriculture, and land management due to their ability to represent terrain features through contour lines. This study introduces a method to customize contour lines using conditional parameters, implemented through Python and ArcGIS. By calculating distances between paired points with the Euclidean formula, the system identifies areas where lines are either too close or too far apart. Points are deleted if they are within a defined proximity threshold, and new points are added when significant gaps are detected. The processed data is visualized in ArcGIS to produce a refined contour map. Applied to an oil palm plantation dataset with 469 points, 154 points (32.84%) were removed, and 4 new points were added. The resulting map better reflects practical land-use requirements, helping optimize layout and resource planning. This approach enhances topographic clarity and supports more efficient terrain analysis.*

Keywords: Contour customization; Euclidean distance; Topographic analysis

1. INTRODUCTION

Topographic maps are essential in civil engineering, environmental planning, and agriculture for visualizing and interpreting land surface elevation. Contour lines on these maps represent elevation levels, offering essential information for terrain analysis, water flow modeling, and infrastructure planning. In plantation agriculture, particularly in the context of oil palm development in hilly regions like Malaysia, these maps facilitate the optimization of land use while considering slope stability, erosion control, and planting strategies [1].

Conventional methods for generating contour lines frequently exhibit insufficient adaptability to particular land-use needs. Many depend on uniform interval rules implemented across entire landscapes, neglecting terrain sensitivity and operational relevance. This limitation results in excessive contour density in flat regions and insufficient representation in critical slope areas [2]. Inaccuracies may lead to inefficient terrace spacing, canopy overlap, and reduced yield potential in oil palm plantations [3].

Many studies have sought to enhance terrain representation and spatial analysis via improved GIS processing. Liu et al. proposed a fuzzy clustering method to segment contour lines, enhancing visualization and processing capabilities [4]. Atit et al. highlighted the significance of user cognition in the interpretation of layered spatial data, underscoring the necessity for simplified and functional contour layouts [5]. In the context of IEICES, Masuda and Hasegawa presented advanced interpolation techniques for terrain modeling [6], whereas Tanaka et al. concentrated on automating elevation correction through GIS-based methods [7].

Additional studies have concentrated on the incorporation of geospatial intelligence into elevation modeling. Ishii and Komura utilized artificial intelligence to examine digital elevation models for the extraction of terrain features [8]. San et al. employed thinning and segmentation techniques for digital topographic conversion, thereby improving the accuracy of automated contour interpretation [9]. Research conducted by Mohd Yusoff et al. utilized ArcGIS in plantation management, demonstrating the direct impact of spatial data on operational efficiency [10].

Khairunnisa et al. investigated slope classification in agricultural mapping to assess land suitability for plantation purposes [11]. Saiful et al. utilized topographic metrics such as elevation, slope, and curvature to enhance precision farming in oil palm areas [12]. Yusof et al. examined the effects of terrain-based planning on palm productivity, highlighting the importance of spatial customization in optimizing yield [13]. Jamil and Mokhtar illustrated the role of GIS-based terrain suitability modeling in enhancing land use for plantations [14]. Meanwhile, Sulaiman et al. integrated digital elevation modeling to refine planning and production accuracy in oil palm development [15].

Despite these contributions, limited methods exist that dynamically modify contour lines through direct point-to-point spatial logic. This study presents a rule-based approach utilizing Python and ArcGIS, wherein point distances are assessed through the Euclidean formula. When the distance between points surpasses a threshold of 30 meters, a new midpoint is introduced. If it falls below the threshold, a point is removed to minimize redundancy. This technique improves topographic clarity and facilitates enhanced decision-making in agricultural layouts based on terrain.

The method was applied to an oil palm plantation in Dungun, Terengganu, processing 469 points, with 154 eliminated and 4 added. The enhanced contour map provided better spatial distribution, minimized visual clutter, and emphasized regions appropriate for further terrace development. This automated workflow offers a scalable GIS solution that is lightweight and adaptable across various sectors.

2. METHODOLOGY

The dataset used in this study represents the topographic layout of an oil palm plantation located in Dungun, Terengganu, Malaysia. Provided by MySpatial Sdn. Bhd., the dataset is in shapefile format and includes contour lines derived from elevation data with a vertical resolution of 5 meters. These contours capture the natural variations in the terrain, which are critical for planning plantation infrastructure such as terraces, irrigation channels, and access roads. The spatial data was projected using the Universal Transverse Mercator (UTM) coordinate system, enabling accurate distance and area measurements in meters. By analyzing this real-world plantation landscape, the study could simulate how spatial customization of contour lines, such as detecting overly dense lines or filling significant gaps, impacts practical land-use decision-making. The dataset thus served as a reliable testbed for validating the proposed method in a context with direct agricultural and economic relevance.

To identify the distance between two contour lines, the most significant data required are the longitude and latitude of points, group of points, and label of points, as explained in Table 1.

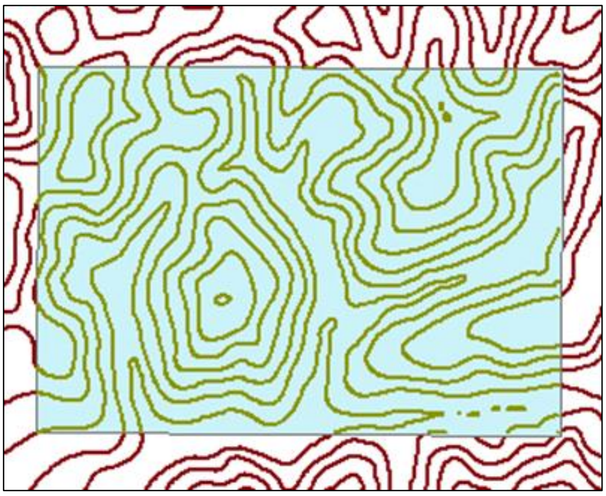
Table 1. Details of Data Requirements

No	Variable	Variable's Name	Variable's Type	Description
1.	Longitude of points	x	float	This variable describes the longitude of a point
2.	Latitude of points	y	float	This variable describes the latitude of a point
3.	Group of points	contour	integer	This variable describes an initial contour line
4.	Label of points	label	string	This variable describes the label of pair of points that are adjacent to each other

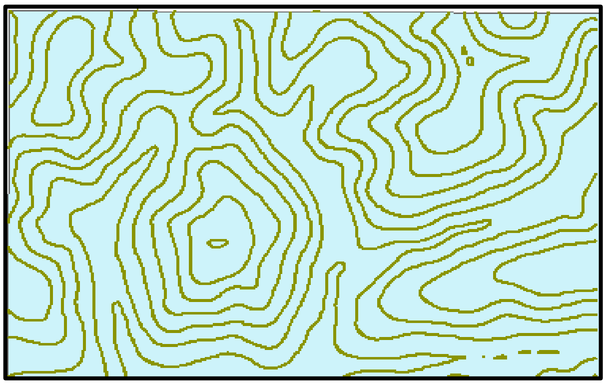
Based on Table 1, all variables are useful to determine, locate, and propose additional points and cut contour lines with defined parameters.

2.1 Converting the Topographic Maps

The topographic map of the oil palm plantation was first processed to generate a contour line map as required as shown in Fig. 1(a). Given the extensive coverage of the plantation area, the dataset was clipped to a defined area of interest using the "Clip" tool in ArcGIS to focus the analysis on a manageable and relevant section of the terrain, shown in Fig. 1(b).



(a)



(b)

Fig. 1. Result of Clipping Shapefile Process

Next, the contour lines were converted into individual points, as illustrated in Fig. 2. Each contour line typically represented as a continuous curve, was sampled at regular intervals to generate coordinate points that capture the line's geometry. These points, each with a defined spatial location, enabled precise calculation of distances between adjacent contour lines. This point-based representation formed the basis for identifying significant gaps or overlaps, allowing the analysis to propose new points or mark contour segments for discontinuation based on defined spatial parameters.

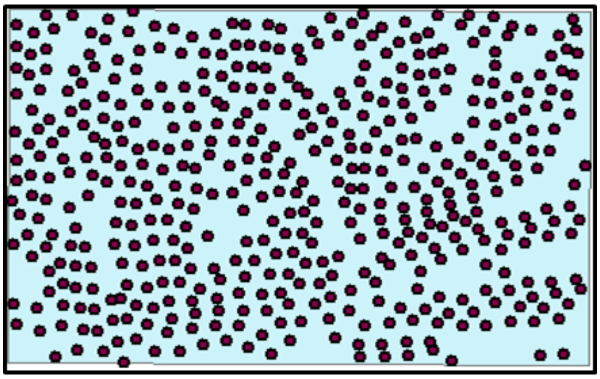


Fig. 2. Result of Converting Contour Line to Points

2.2 Labelling points

The attributes of the generated points were stored in the associated attribute table, as shown in Fig. 3. Initially, these points were spatially scattered without any identifiers linking them to their respective contour lines.

To address this, each point was labeled in ArcGIS according to the contour line it originated from, using a unique identifier stored in the "contour" column. To facilitate distance calculations, points from adjacent contour lines were paired and assigned combined labels. For example, point pairs from two neighboring contours might be labeled as B2 and C2. This labeling was recorded in a new column named "label" and applied consistently across the dataset, including the outermost points. Additionally, each point's UTM coordinates were extracted and stored in separate fields: "x" for easting and "y" for northing. The fully labeled and georeferenced dataset was then exported as a CSV file for further analysis in Python.

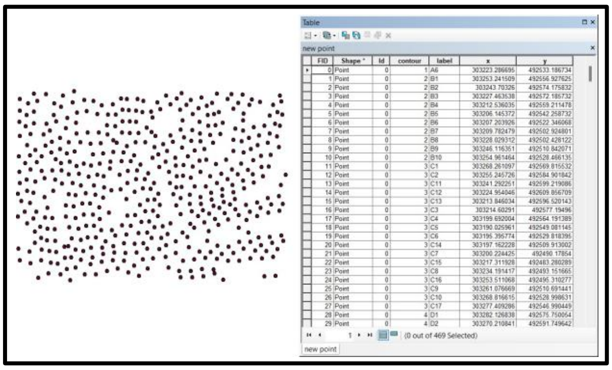


Fig. 3. Result of Labelling Points and Generating Coordinate

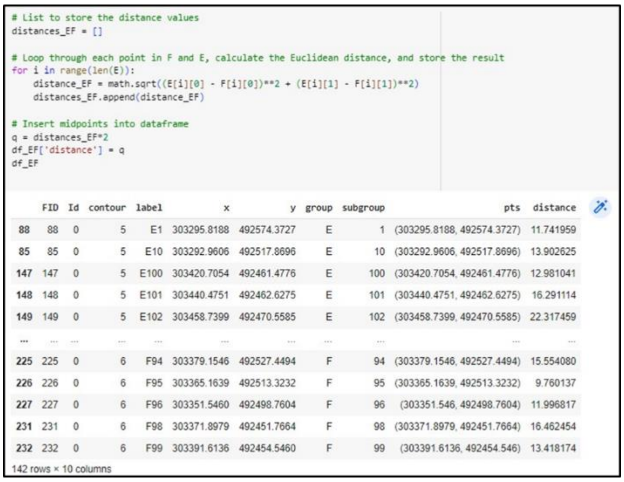
2.3 Calculating Distance Between Points

To calculate the distance between points, Euclidean Distance is used by substituting the coordinates of the points as shown in Equation 1 below.

Distance between two points:

$$\sqrt[2]{(x_2 - x_1)^2 + (y_2 - y_1)^2} \tag{1}$$

The point data in the variable 'pts' is initially divided into distinct lists according to their corresponding contour group labels. For example, all points related to Group E are contained in list E, whereas points from Group F are contained in list F. This arrangement enables systematic pairwise comparison of neighboring contour lines. A loop function is employed to iterate through both lists, utilizing the Euclidean distance formula to compute the straight-line distance between corresponding points in sequence. The computed distances are subsequently added to a new column titled 'distance' in the Python dataframe, with values represented in meters. This output, depicted in Fig. 4, establishes the basis for deciding whether points should be retained, removed, or utilized to generate midpoints according to a specified spatial threshold.



```
# List to store the distance values
distances_EF = []

# Loop through each point in F and E, calculate the Euclidean distance, and store the result
for i in range(len(E)):
    distance_EF = math.sqrt((E[i][0] - F[i][0])**2 + (E[i][1] - F[i][1])**2)
    distances_EF.append(distance_EF)

# Insert midpoints into dataframe
q = distances_EF*2
df_EF['distance'] = q
df_EF
```

	FID	Id	contour	label	x	y	group	subgroup	pts	distance
88	88	0	5	E1	303295.8188	492574.3727	E	1	(303295.8188, 492574.3727)	11.741959
85	85	0	5	E10	303292.9606	492517.8696	E	10	(303292.9606, 492517.8696)	13.902625
147	147	0	5	E100	303420.7054	492461.4776	E	100	(303420.7054, 492461.4776)	12.981041
148	148	0	5	E101	303440.4751	492462.6275	E	101	(303440.4751, 492462.6275)	16.291114
149	149	0	5	E102	303458.7399	492470.5585	E	102	(303458.7399, 492470.5585)	22.317459
...	...	...	...	...	...	...	...	...	...	...
225	225	0	6	F94	303379.1546	492527.4494	F	94	(303379.1546, 492527.4494)	15.554080
226	226	0	6	F95	303365.1639	492513.3232	F	95	(303365.1639, 492513.3232)	9.760137
227	227	0	6	F96	303351.5460	492498.7604	F	96	(303351.546, 492498.7604)	11.996817
231	231	0	6	F98	303371.8979	492451.7664	F	98	(303371.8979, 492451.7664)	16.462454
232	232	0	6	F99	303391.6136	492454.5460	F	99	(303391.6136, 492454.546)	13.418174

142 rows × 10 columns

Fig. 4. Result of Generating Distance of E-F Pair of Points

2.4 Proposing Points When Defined Parameters is Met

The distance between each pair of points is used to determine the distances between two adjacent contour lines. In this study, a threshold parameter of 30 meters was defined. When the distance between paired points exceeds this threshold, a new point, specifically a midpoint is generated and inserted between them to mark a significant spatial gap.

Since this study is related to oil palm plantations, the parameter of 30 meters defined will have a significant impact on the sector. Typically, terraces for planting oil palm trees are aligned along contour lines to manage water flow and erosion effectively. When large gaps exist between contour lines, they may indicate underutilized land that could support additional terraces. By identifying and proposing midpoints in these areas, the method enables more efficient land use planning. These additional points serve as strategic references for expanding planting areas, ultimately contributing to increased plantation yield and improved land productivity.

2.5 Proposing the Discontinued Contour Line

In contrast to the addition of new points, the method also identifies where contour lines should be discontinued. This occurs when the distance between a pair of adjacent points is less than the defined threshold of 30 meters. In such cases, one of the points in the pair is removed to reduce unnecessary contour density, effectively "cutting" the contour line in areas where elevation changes are minimal or redundant.

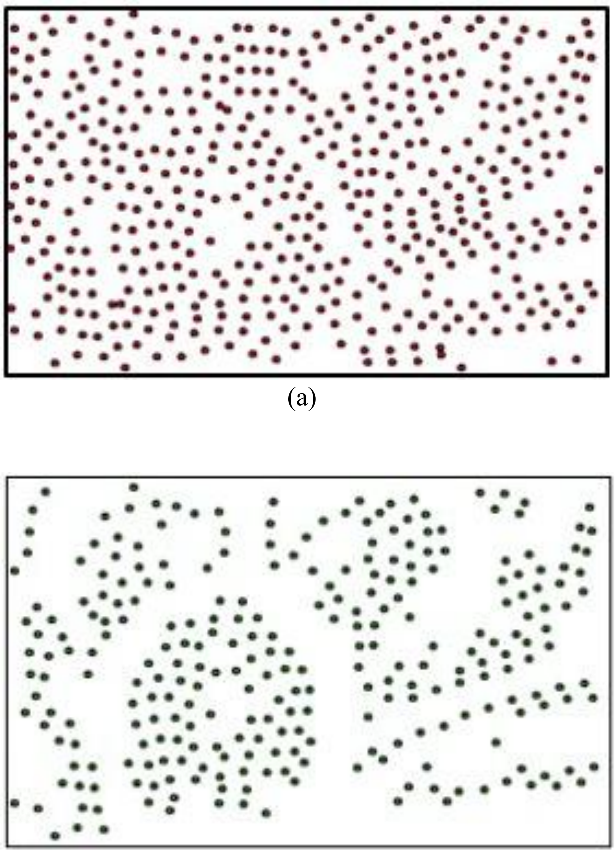
This adjustment has practical implications for the oil palm plantation industry. Closely spaced contour lines often lead to the construction of terraces that are too near each other, resulting in overcrowding. When oil palm trees are planted too closely, their canopies tend to overlap, reducing sunlight exposure and airflow—factors that directly affect fruit quality and yield. By removing excessively close points and refining contour placement, plantation managers can optimize tree spacing, improve growing conditions, and ultimately enhance both productivity and profitability. This process also promotes a deeper understanding of topographic characteristics that inform better land-use decisions.

3. RESULTS AND ANALYSIS

As illustrated in Fig. 4., the red points in (a) represent the original set of points before analysis, while the green points in (b) indicate the refined dataset after applying the distance-based filtering process. Using the defined threshold of 30 meters, the algorithm evaluated the Euclidean distance between each pair of adjacent points. When the distance between two points was found to be less than the threshold, one of the points was flagged for removal to reduce spatial redundancy along the contour lines.

After the filtering process, a total of 154 points were deleted from the original 469 points, representing a reduction of 32.84%. This significant decrease highlights the prevalence of closely spaced contour segments in the original map, which could lead to overly dense or unnecessary terrace construction in plantation planning. By removing these redundant points and updating the contour structure accordingly, the resulting map offers a cleaner and more practical layout for real-world implementation, especially in optimizing land use for oil palm cultivation.

This point reduction not only improves the visual clarity of the map but also provides operational benefits. Fewer, more strategically placed contour lines reduce the likelihood of overlapping plantation rows, promote better spatial planning, and ensure that each new terrace is justified by meaningful elevation changes. This enhances both the efficiency and economic viability of oil palm plantation design.



(a)

(b)

Fig. 4. Comparison of Points Between Before (a) and After (b) Deleting Points

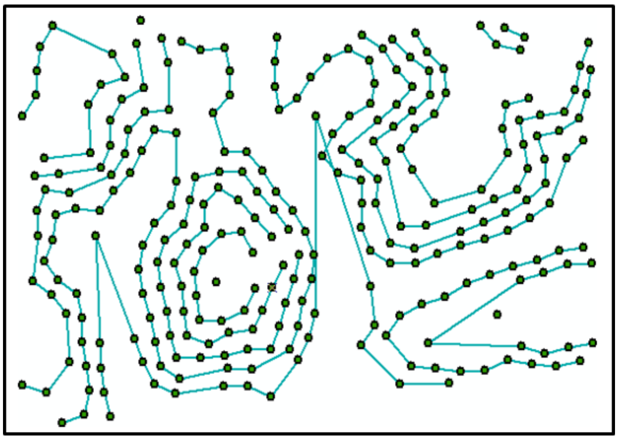


Fig. 5. New Generated Contour Line with New Points

Fig. 5 illustrates the newly created contour lines, obtained from the subset of points that met the specified spatial threshold of 30 meters. The lines were produced in accordance with the study's second objective, which entailed the removal of redundant locations where neighboring distances fell below the threshold. The filtering method has produced reconstructed contour lines that exhibit sharper, more angular forms, particularly at transition points where data points were removed. The existence of "pointy" or jagged edges results from the disturbance of the natural curvature of the original contour lines, due to the elimination of closely spaced points that previously maintained their smooth geometry.

The geometric modification is clearly evident when comparing the updated contour map with the original, as demonstrated in Fig. . The original contour lines display enhanced fluidity and continuity, signifying a more complex network of elevation points. The revised map, while more streamlined and space-efficient, displays sudden angular transitions due to the absence of intermediate points. This visual disparity underscores the compromise between data simplification and aesthetic or topographic coherence.

The irregular appearance, commonly viewed as a disadvantage, really signifies the improved efficacy of the novel mapping method. The aim is to emphasize substantial elevation changes rather than to achieve perfect natural smoothness and to eliminate superfluous terrain duplication. The defined contours serve a practical purpose by guiding more strategic land development choices and reducing the risk of excessive planting in regions with slight elevation differences.

The disparity between the altered contour lines and the original ones, as illustrated in Fig. 6, emphasizes the variation in smoothness of the contour lines.

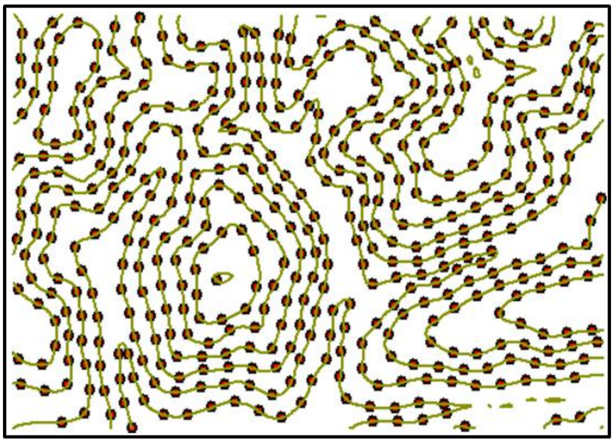


Fig. 6. Figure Original Contour Line and Points

A point is identified when the distance between two contour lines surpasses the established parameter. A point, referred to as the midpoint, is generated between a pair of points based on the calculated distance between them. The midpoints are plotted in ArcGIS as Fig. 7.

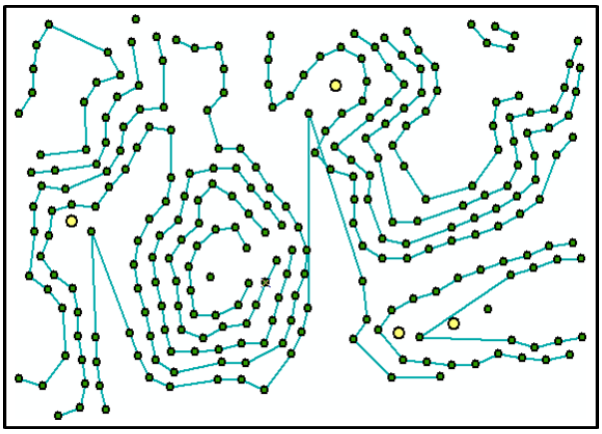


Fig. 7. Marked Points on New Contour Map

Fig. 7 illustrates the plotting of four yellow points on the customized contour map. These points were derived during the spatial analysis phase, particularly where the distance between adjacent contour points surpassed the established threshold of 30 meters. A new midpoint was calculated and inserted to address the spatial gap, thereby preserving the continuity and representation of the terrain. The yellow points serve as indicators of significant elevation gaps, highlighting areas where the original topographic data did not possess adequate resolution to capture subtle yet important variations in the landscape.

The presence of marked points is essential for improving the accuracy and completeness of the contour map. Visual cues are provided to identify underutilized or overlooked areas of the terrain, especially in flatter regions where elevation changes are less pronounced yet remain operationally significant. In agricultural contexts, such as oil palm plantations, these gaps may indicate locations appropriate for further terrace development or enhanced water flow management. Identifying and addressing these intervals allows planners to optimize land use efficiency, minimize wasted space, and improve overall productivity.

Additionally, these yellow points enhance the spatial distribution of contour lines throughout the map. The automated insertion of midpoints, based on actual spatial metrics, enhances contour representation by ensuring it is data-driven and responsive to real-world terrain conditions, rather than relying solely on uniform spacing or manual adjustments. This enhances the visual clarity of the map and facilitates more accurate terrain interpretation for decision-makers and field engineers.

The inclusion of these four yellow points, while limited in number, significantly enhances the map's functional value. Their placement enhances the contour map, rendering it a more effective tool for topographic analysis. This enables users to identify subtle landscape features that may affect planting layout, drainage design, or accessibility, thus underscoring the significance of incorporating conditional spatial logic into contour customization processes.

4. CONCLUSION

This study presented a geographically adaptive technique for tailoring contour lines on topographic maps with conditional parameters, executed via Python scripting and ArcGIS tools. By examining inter-point distances with a 30-meter threshold, the system dynamically modified contour density, eliminating superfluous points and incorporating new ones where substantial elevation discrepancies were present. This approach produced a more efficient and comprehensible contour map appropriate for practical land-use planning.

The approach applied to an oil palm plantation in Dungun, Terengganu, analyzed 469 points, of which 154 (32.84%) were eliminated owing to proximity, and 4 midpoints were suggested to mitigate bigger gaps. The resultant contour lines enhanced landscape representation, minimized clutter, and revealed previously neglected regions suitable for development into productive plantation terraces.

In addition to technical advancements, the research has immediate ramifications for agricultural enhancement. Minimizing overlap in planting zones and strategically augmenting usable area enhances resource management, optimizes agricultural output, and increases operational efficiency.

This method illustrates how straightforward, rule-based spatial logic, when integrated with geospatial tools, can yield significant enhancements in topographic analysis. Future endeavors may encompass GUI development, interaction with slope models, and application to many terrain types to enhance its utility across several sectors.

5. ACKNOWLEDGEMENT

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