

Exploring the Topographic Characteristics of Settlement Toponyms in Taiwan

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ABSTRACT:

Toponyms are names that people give to places, reflecting people's perceptions and emotional connections to their surrounding environment. Taiwan's rich natural and cultural resources are reflected in the diversity of toponyms. By using term frequency analysis of the 42,871 settlement names, listed in the Geographical Names Database of the Ministry of the Interior, Taiwan, we have identified important generic names related to topographic features, which account for about 28% of all the settlement names. This finding suggests that topographic features are one of the main factors affecting people's environmental perceptions and choices for location of settlements. Based on the above-mentioned investigations, this study intends to explore distribution patterns of topographic places names in geological / topographic aspect and calculates their geomorphometric properties by using Digital Terrain Models. The settlements named after *Lun* (崙), a bulged feature, are specifically investigated to find out how topographic place names are related to their surrounding environment. We found that most of *Luns* on the alluvial plain in southwest Taiwan are highly related to river channels. Due to the quick environmental change, most of the *Luns* no longer preserve bulged shape. To sum up, this study used toponyms as big data to analyze spatial distributions of topographic names of whole Taiwan and their geomorphometric and geologic characteristics. Different from previous research that tended to focus on local scale by linguistic or historical approaches, this study

adopted GIS-based approaches with a macroscopic perspective and highlighted places-names as an important indicator for environmental change. It is expected that the research results can be applied to a wide range of relevant issues, such as environmental perceptions, disaster preventions, geology / geomorphology conservation, geography education, and so on, with both academic and practical values.

1. BACKGROUND

1.1 Diversity of toponyms in Taiwan

Toponyms are geographic information carrying rich meanings. Due to diverse environments and cultures, Taiwan has accumulated a large number of place names throughout history. The early inhabitants gave specific name to the place they lived either to reflect their cognitions toward environment or to document the history and development of that place. Thus, toponyms are precious resource of geography, environment, history and culture. In other words, toponyms are phenomena that evolved over time along with constant changes of natural environment, social development and human activities. Toponyms are like fossil layers, with multiple names in a place, each reflecting the interaction of a particular ethnic group with the environment in a particular time and space.

1.2 Place names database of Taiwan

Previously, toponyms were stored mainly on maps and cadastral data. With the development of GIS, these data have been converted into digital format. The Ministry of the Interior (MOI), the authority in charge of the mapping and documentation of place names in Taiwan, has established a toponyms database and maintained a website for place name service. This database has accumulated over 170,000 place names, including some 42,000 settlement names. This database provides rich and complete information regarding each place, including its name (meaning and pronunciation), location, the origin of name, features and so on. With a format compatible with common GIS software, this database can be easily handled and analyzed either using its spatial data or attribute table.

1.3 Topographic place names in Taiwan

With the database from the MOI, this research has examined the contents of the place names of entire Taiwan. Officially, the place names of Taiwan are written by Chinese characters, although they originate from various linguistic groups, including Fukien, Hakka, indigenous peoples, and foreign rulers like Dutch and Japanese¹. To identify important characters used for place naming,

¹ The place names in Taiwan originated from different Chinese ethnic groups, indigenous peoples and foreign settlers or rulers. Despite these various linguistic sources, the place names are officially represented by Chinese characters.

we first conducted words frequency analysis for the roughly 42,000 settlement names contained in the database. The results show that the top 100 terms of highest frequency have covered 90% of Taiwan's settlement names. Among these 100 terms, nearly 30% of them are related to terrain features, such as *Keng* (坑; pit or tunnel), *Shan* (山; mountain) and *Pu* (埔; plain). This type of names are usually generic names combined with specific names like *Da* (大; big), *Shin* (新; new), *Shang* (上; up) to give further details about environmental features. The wide adoption of terrain features suggests that early settlers were sensitive to topographic characteristics and often named a place based on their environmental perceptions.

1.4 Research topic

Among the many topographical names, *Lun* (崙) has a unique feature. Previous studies indicated that the place names with *Lun* are widely distributed in the vast plain of southwest Taiwan and normally such place names suggested a terrain feature of sand dunes, either along the river bank or coastal area (Chen 1994). In this study, we will focus on *Lun* to explore their distribution and morphological characteristics. By using the data from the MOI and GIS tools, this research intends to explore the relationship between place names and environmental characteristics at nation-wide scope.

2. LITERATURE REVIEW

The application of GIS in the study of place names mainly emerged in the early 2000s. The breakthrough brought about by the combination of GIS and various disciplines is that the spatial analysis of place names can take a more macro- and diversified scale. In addition, the subject matter can be compared with multiple attributes, for instance, how place names are influenced by factors such as topography, rivers, land use, population (Frajer and Fiedfor, 2018). Most importantly, with GIS, it is possible to conduct spatial analysis to measure attributes of place names more accurately

Luo et al. (2009) used GIS to explore the distribution status of Tai's (傣) place names in southern China and Indo-China Peninsulas, from which to examine the topographical characteristics of these geographical names, and then proved that these geographical names are highly correlated with land use patterns in water fields. Sousa et al. (2010) used Spain's military maps from 1869 to 1987 to identify wetland place names and speculated the age of the emergence and disappearance of wetland, and further analyzed the correlation between these wetlands and climate warming at the end of the 19th century. Spens (2006) analyzed the 1,509 old lake names that had disappeared in northern Sweden, compared to maps of the 17th to 20th centuries, and conducted interviews with the Fisheries Management Association to reconstruct the habitat of trout lakes that had disappeared as a result of industrial development after the

1930s as a basis for the species' habitat redevelopment. Frajer and Fiedfor (2018) used the names of the lakes used for fishing, querying with keywords and combining maps of each period to analyze the distribution trends and disappearance phases of lakes in the Czech Republic between the 18th and 19th centuries. It is also used to predict potential areas for possible water shortages or drought in the future.

Fuchs (2015) refers to the above type of studies as "toponymic GIS", which, like the term "historical GIS", uses GIS tools to integrate data from place names across time and space for studies that traditional qualitative research cannot handle. At the same time, the visualization of GIS to show a variety of maps and statistical charts, the display of geographical names can thus cover a richer and more diverse information, that is, the presentation of the combined point distribution and polygon map.

Although the topographic place names were given by the early inhabitants according to the appearance of the landscape, these geographical names may have geological and topographic significance. In recent years, topographical and geological research has relied heavily on digital terrain models (DTM) data. For example, tectonic topography and geology research often uses high-resolution DTM to use linear features as clues to the search for active faults, while river breeding studies can also use numerical analysis and aerial photographs to identify river terraces and to evaluate river breeding based on their distribution and size.

3. RESEARCH QUESTIONS

There are many *Lun* place names distributed in the vast plains of the south-west Taiwan. From the observation scale of the inhabitants, what kind of topographic features will be named as *Lun*? The dome shape of *Lun* makes it outstanding on extensive plain, thus often adopted by early settlers as place names. As *Lun* is most likely formed by sand dunes along river bank or coast zones, the distribution of *Lun* is crucially indicating the locations of early river or coastline. This study uses DTM models to explore and summarize the common features of the locations of these terrain sits by using geometric pointers such as height, height difference, slope, area and slope length. For example, how high and how big is the average *Lun*? Research questions are as below.

- (1) The shape of *Lun*: Supposedly, *Lun* is a small hill arising on plain and demonstrating a dome shape. Yet, how big and how high that such small hill be considered as *Lun* is yet to be found out. This study will identify the location of all places named after *Lun* and explore their terrain characteristics using DTM data. By doing so, we hope to find out the shape of *Lun*.
- (2) Terrain environment background
Lun is generally considered to be the location of sand dunes, accumulating along coasts

and river banks. The plains of southwestern Taiwan, caused by river accumulations, used to flourish and the coast was moving out very quickly. The inland plains of today may have been seafront hundreds of years ago. In addition, the environment on the alluvial plains changes quickly due to both human and physical factors. This research will explore the distribution of *Lun* to find out the relation between them and rivers/coast lines.

(3) Preservation of *Lun*

If the luminous sand dunes are formed, their composition is loose, very vulnerable to changes in natural forces such as wind, but also because of man-made land use development (farmland, housing) changes. As a result, *Lun* may disappear very easily. This study will explore how many *Luns* maintain their outlook.

4. RESEARCH METHODS

4.1 Research data

The data being used in this research include place names and DTM. The place name with *Lun* are extracted from the toponym database maintained by the MOI. We have identified the location of each settlement place name previously and will use these locations to further analysis of their distribution patterns.

The DEM used by this research is also produced by the MOI of Taiwan. The horizontal resolution of this DTM is 20 meters while the vertical resolution is 1 meter. In fact, another DEM of Taiwan in 5 meters horizontal resolution is available as well. Yet, after examination, we found the data quality of 5M DEM is not as good as 20M DEM, thus this research adopted the latter.

4.2 Research tool

This research used ArcMap 10.7 to explore place names and DEM. In order to examine the characteristics of each place name with *Lun*, we used Matlab software to extract the windows embedding each *Lun* place name. The data window being extracted include different size, starting from 3X3 to 13X13 with the *Lun* place name in the center. We calculated the terrain feature for each *Lun* place name at these varied window sizes. For each window, we calculated the following values:

- Height difference within window;
- Height ranking of the central grid (where *Lun* located) compared to all grid height;
- Average slope of the whole windows.

5. RESULTS AND DISCUSSION

5.1 *Luns*' elevation and location

We extracted a total of 580 settlement names with *Lun* from the place names database by MOI.

We plotted these settlements on the terrain relief map derived from the 20M DEM (Fig. 1). As shown on the map, most of *Lun* settlements are located on the southwestern plain of Taiwan. Yet, there are *Lun* place names on mountain area as well. Using the grid elevation of each *Lun* name, we obtained a histogram to show the elevation range and distribution of *Lun* (Fig. 2). As this figure shows, nearly 80% of *Luns* are located lower than 100 meters, the threshold considered as plain in Taiwan, while the other 20% are located higher than 100 meters, with the highest elevation over 1000 meters. The *Luns* on mountain area might be formed by tectonic movement or other reasons and have nothing to do with rivers or coast sand dunes. Thus, we excluded them in the following analysis. Those *Luns* under 100 meters are subject of following analysis and shown on Fig. 3.

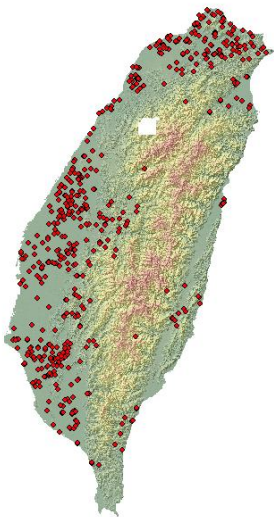


Fig. 1 Locations of *Luns*

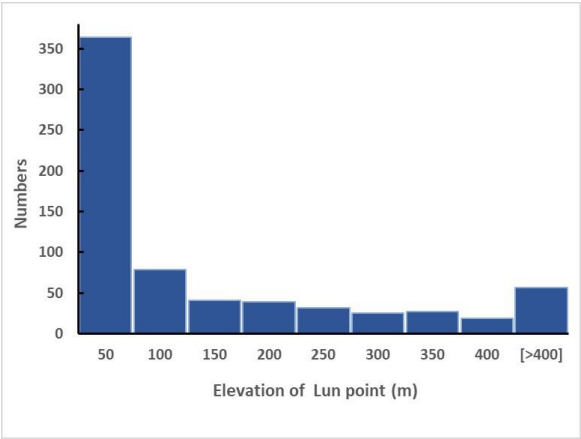


Fig. 2: Histogram of *Luns*' elevation

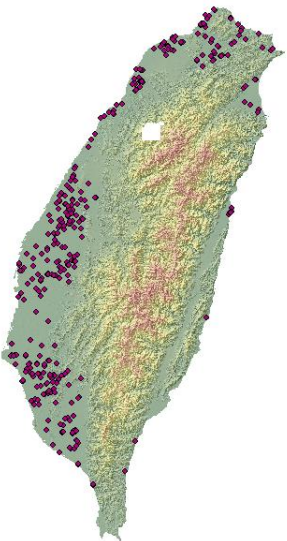


Fig. 3 Locations of *Luns* under 100M.

5.2 Locations of *Luns* relevant to rivers and coastline.

For those *Luns* under 100 meters height, we further examined their locations. Through intensive observation for each *Lun*, we found most *Luns* located in inland area instead of along coastline. Closer investigation by enlarging the display, as Fig. 5 shows, we can identify that most of these inland *Luns* are nearby river channels, suggesting that most *Luns* on the alluvial plain were created by sediment from river banks, instead of ocean. Furthermore, we found this type of river bank *Lun* more likely to occur in southern side of river than northern side. This phenomenon may relate the pervasive wind direction of Taiwan during winter season is north-east. We do not want to jump to conclusion on this phenomenon as more strict research are needed, yet this clue surely deserves efforts in future study.



Fig. 4 Sample A: *Lun* located by river.



Fig. 5 Sample B: *Lun* located by river.

5.3 *Luns*' shape

We expected that a typical name of *Lun* will demonstrate an elevated terrain around the central area, as shown in Fig. 6 and Fig. 7.

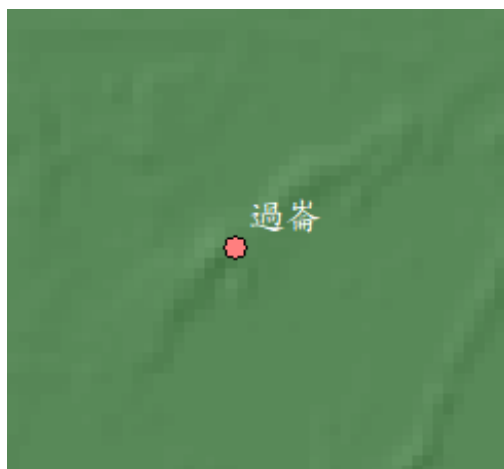


Fig. 6 Sample *Lun* with uplifted center.



Fig. 7 Sample *Lun* with uplifted center.

Yet, we found this typical shape does not commonly exist. By calculating the height difference (HD) within each neighboring window of *Lun*'s site, we can use HD as indicator that whether the shape of *Lun* is preserved. Figure 8 shows the variation of HD for each *Lun* site. Figure 9 is an enlarged one for a portion of area. As the graduated symbols show, not many *Lun* sites present a HD higher than 2 meters, not to mention 5 meters. We further plotted a histogram (Fig. 10) to show the value and range of HD in the area. Histogram of figure 11 shows the average slope of each *Lun* with a neighboring window of 11 by 11. As these two figures show, most of the *Lun* in southwestern Taiwan are flat now, suggesting they have been leveled. One reason might be that this area has been developed as farmland or built-up area and therefore, the preservation of *Lun* is difficult. The smallest symbol of this map represents HD smaller than 2 meters.

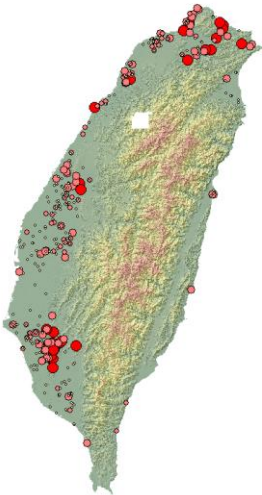


Fig. 8 Graduated symbol showing HD

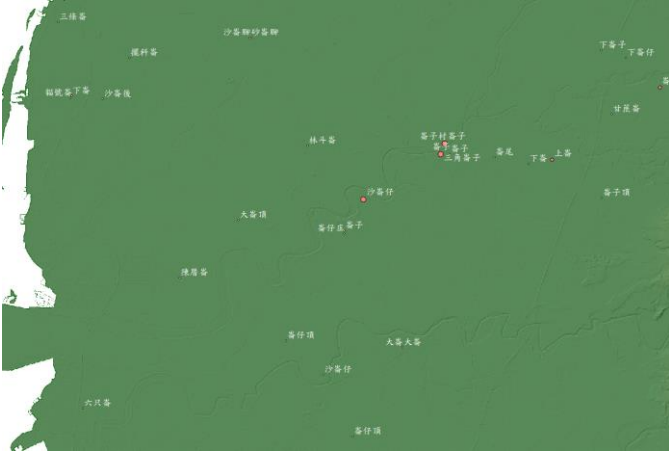


Fig. 9 Sample area showing varied HD of Lun

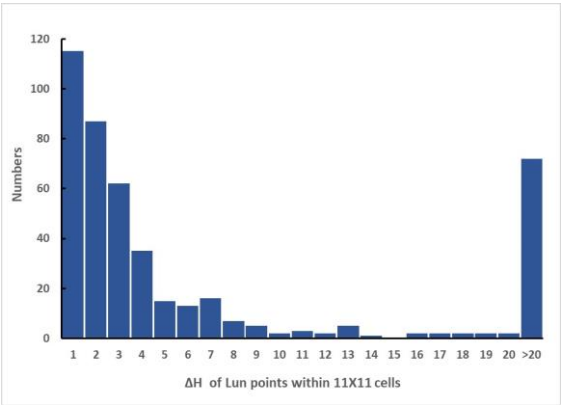


Fig 10. Histogram of HD

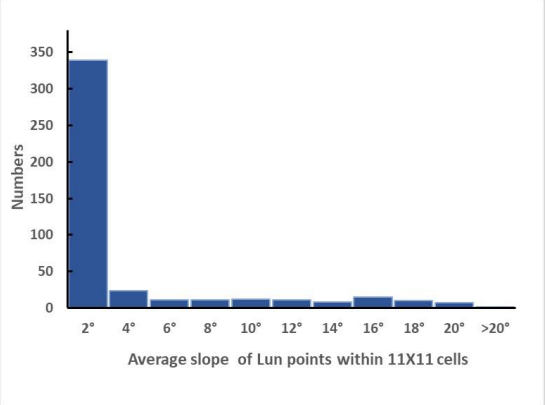


Fig 11. Histogram of average of slope within *Lun* window

6. CONCLUSIONS

Previous studies on toponyms in Taiwan mostly investigated individual cases in local scale. This study took advantage of place names database and applied GIS to comprehensively explore the distribution and environmental characteristics of *Luns*, a place name indicating special terrain relief. The results showed that such approach could be promising in expanding research topics of toponym research. With GIS, this research visualized the spatial distribution and calculated the height ranges of *Luns* in Taiwan. Overlaid with topographic relief map, it is clear to see that many of *Luns*' locations are close to rivers, suggesting their formation related to sand dunes along river banks. This study also found that a large number of *Luns* have been flattened, indicating quick landform changes occurring in Taiwan.

This research is a pilot study to test the applicability of using place names databases, GIS and DEM to measure topographic characteristics. Our future study will further investigate the location of *Luns* related to river channels and wind directions. As terrain feature like *Lun* is composed of soft materials and easily subjected to environment change, either by human or physical forces, we will try to investigate terrain features which are more resilient to environmental changes.

REFERENCE

1. Chen G-C., 1994. Studies of Taiwan's Toponyms, Geographical Studies No.24, Department of Geography, National Taiwan Normal University.
2. Frajer J. and Fiedor, D., 2018. Discovering extinct water bodies in the landscape of Central Europe using toponymic GIS, *Moravian Geographical Reports* 26(2):121-134.
3. Fuchs, S., 2015. Toponymic GIS - Role and potential of place names in the context of geographic information systems, *Kartographische Nachrichten* 65(6):330-337.
4. Luo, W., Hartmann J. F. and Wang F., 2009. Terrain characteristics and Tai toponyms: a GIS analysis of Muang, Chiang and Viang, *GeoJournal* 75(1):93-104.
5. Sousa, A., García-Murillo P., Morales J., Sahin S., García-Barrón L., 2010. Wetland place names as indicators of manifestations of recent climate change in SW Spain (Doana Natural Park), *Climatic Change* 100(3):525-557.
6. Spens, J., 2006 Can historical names and fishers' knowledge help to reconstruct lakes? In: Haggan N, Neis B, Baird IG (eds) *Fishers' knowledge in fisheries science and management*. Blackwell Science, Oxford, pp 279–289