Study of Landscape Indices Analysis in Establishment Principles of Administrative Zones in Taiwan

Yung-Chung Chuang Yu-Chi Kao Re-Yang Lee
Department of Urban Planning and Spatial Information, Feng Chia University, No. 100, Wenhwa Rd., Seatwen, Taichung, 40724 Taiwan (R.O.C.)

Abstract

We attempt to introduce ideas of spatial overlays and landscape indices analysis in zoning principles in Taiwan. First, we compared overlaying level of boundary of catchments area and administrative zone boundary to present levels of impacts of terrains on administrative zone separation. From village distribution digitization results in Taiwan Map in 1904 and topographic map in 2001, we explored influences of village locations, distribution density, and concentration level on administrative zone separation in the two periods. It showed that the average administrative zone area in Taiwan western plains has been reduced more than eastern mountainous area in the past century. Spatial distribution characteristics of villages in all administrative zones tend to be homogenous due to the prosperous settlements and traffic network development, but the expansion rate of village and the addition rate of administrative zones in western plains are significantly higher than those in eastern mountain areas because of the less terrain restriction. For this reason, administrative zones have been rarely adjusted in eastern Taiwan. The areas are mostly overlapped with catchments boundary. In other words, changing thresholds of administrative zones in eastern mountain areas are higher than those in western plains.From the results of the research, one can find that GIS spatial overlays landscape indices analysis effectively present village distribution differences in different areas and the trend of administrative zone changes. It is also proves good application of catchments separation method in places with obvious rise and fall. The quantitative results will help future administrative zone separation adjustment.

Keywords: administrative zones, GIS, Landscape Indices Analysis

Introduction

Administrative zones are the result of structure in different levels of national lands divided by government institutes in consideration of administration management. Allocation methods, principles of administrative zones, sizes and changes are affected by terrain features, traffic construction, economic development, population and political systems. Based on preceding paragraph, overall, boundary of administrative zones is virtual boundary. In most research, it is not easy to analyze such issues with spatial quantitative analysis. It is difficult to explain and position in text description, resulting in different interpretations of administrative zones allocation in different periods (Reis and Raper, 1994). With development of geographic information processing technology and spatial statistics models, natural and human phenomena in geographic space can be arranged and concluded with statistic indices and spatial overlays to analyze the regular patterns of changes; prediction can even be made with mathematic models. For

example, Martin (1991), Openshaw and Rao (1995) successfully use geographic information system inference model to reconstruct population distribution of administrative zones in England in different periods and win certification. Thus, we attempt to introduce ideas of spatial overlays and landscape indices analysis for establishing zoning principles in GIS platform.

Materials and methods

This paper covers Taiwan administrative zones in two periods (1904 and 2001) (Fig. 1). The research is divided into two parts. The first one explores influence of administrative zones allocation under natural terrain from overlaying Taiwan catchments boundary and administrative zones boundary in 2 periods; the second part discusses correlation between village distribution and administrative zones boundary with spatial overlays and landscape indices, covering relation between village forms, distribution density and scattering level in single period and administrative zones characteristics also the trend of changes of village spatial locations and administrative zones adjustment.

The study materials are geographic information that regular researchers have access to, including Taiwan 40 m × 40 m digital topography model, 1904 "Taiwan fort map" (in scale of 1/20,000), and 2001 topographic map by Ministry of Interior (in scale of 1/25,000). Digitization on administrative zones boundary, villages and buildings is on the preceding 1904 Taiwan fort map and 2001 topographic map (hall/ fort /and village boundary in 1904 Taiwan fort map; county/city, town/township and village boundary in 2001 topographic map). The analysis methods are:

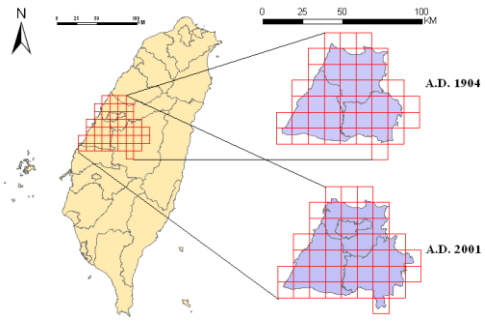

Fig. 1 Study Areas

We generated virtual boundaries by using catchment division method and compared with real administrative zones boundary. We used Taiwan 40 m × 40 m grid digital terrain model and 8-flow direction algorithm in Arc/Info Grid module to automatically extract contributing area layer and stream layer. Based on 3rd stream order, we generated catchments and sub-catchments boundaries. The defined catchments boundary was overlapped on boundary of halls, forts and villages in Taiwan fort map in 1904 and boundary of cities/counties, towns/townships and villages/lis in topographic map in 2001 to make comparison.Other than comparison of catchments boundary, river system and administrative zones boundary compliance in 2 periods, as many mathematic indices in landscape ecology analysis effectively present spatial characteristics and differences with numbers or grades, we used central Taiwan as an example (Fig. 1) to combine village locations, distribution layer and administrative zones in the 2 periods. We calculated landscape indices of village and administrative zones in 2 periods with 10 km × 10 km num-

bered basic unit frame (Fig. 1) and compare the regional differences.With landscape indices analysis, we explored and compared administrative zones allocation principles and regular pattern of changes. Later we can infer influence of village distribution on administrative zones allocation in 2 periods.

Results and discussions

Fig. 2 shows current that overlapping of city/county and catchments boundary in Taiwan exceeds a certain level. Central and eastern cities/counties in Taiwan in higher elevation have best overlapping level. Scope of a lot of towns and townships still follow catchments boundary or are divided from sub-catchments scope. In western plains, from Fig. 2 or Fig. 3, there are more exceptions in either 1904 or 2001. Most of them are caused by low hills or Irrigated system. Where catchments and stream system location can't explain or only partial stream system and catchments boundary serve as administrative zones boundary.

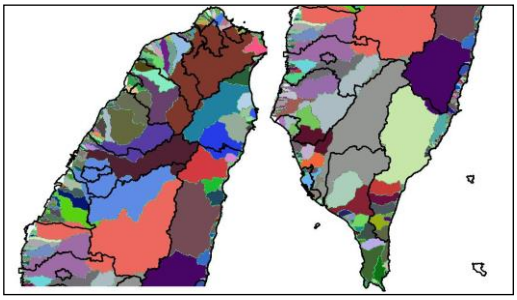

Fig. 2 Current administrative zones in Taiwan, catchments boundary from catchments division method, and city/county boundary (black boundary), have high overlapping rate

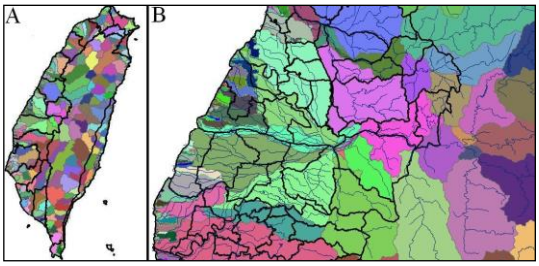

Fig. 3 In hall (A) and fort (B) boundary in Taiwan fort map, catchments boundary and stream system locations (solid bottom) from catchments division method are only partly overlapped with administrative zones boundary (black boundary), meaning that terrain and stream system were not the only determining factor of boundary then.

Other than terrain factor, population distribution is also a main factor. With the example of central Taiwan that represents population distribution village spatial distribution layer, we explored the influence on administrative zones allocation in the 2 periods. In central Taiwan close to mountain areas, villages were not as developed as those in western plains in the 2 periods. Most villages were still confined in valleys or intersection of river courses in catchments. Areas only slightly increased or villages slowly expanded upwards along stream system (Fig. 4). Village location selection and cultivation lands in mountain areas were greatly affected by terrain. Development could only be possible in gentle slopes,

river terrace, river beach lands, sand bars and river highlands with gentle gradient and thicker soil layer. Villages were in fragmented, scattered or partial distribution.

Comparing administrative zone characteristics in western plains and eastern mountain areas in the 2 periods, halls correspond to cities/counties (highest level), forts correspond to towns/townships (middle level) and villages correspond to village (basic level). Administrative zone characteristics of western plains show greater changes than those of mountain areas and neighboring areas in the 100 years (Fig.6). From Fig. 7, in both 1904 and 2001, villages with denser population had smaller and concentrated administrative zones. Number of increased administrative zones in the past 100 years is significantly higher than that in other areas; places with denser population were mainly in western plains. This shows lower separation effect of terrain and stream system in western plains; the main driving force to changes is villages and population additions.

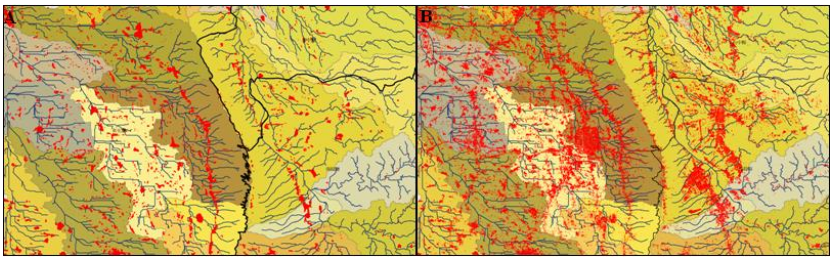

Fig. 4 Spatial distribution relation between villages in Changhua Plains (red) and catchments stream system (blue lines) and boundary, (A)1904, (B)2001

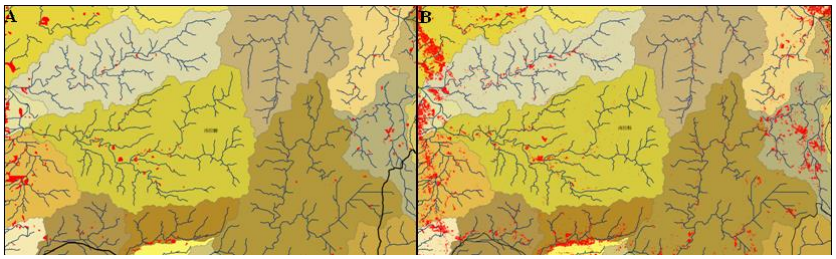

Fig. 5 Spatial distribution relation between villages in Nantou mountain areas (red) and catchments stream system (blue lines) and boundary, (A)1904, (B)2001

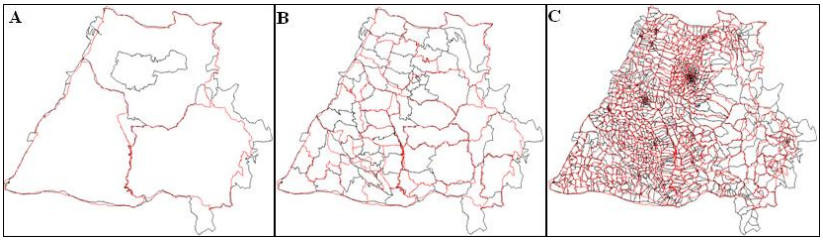

Fig. 6 Comparison of administrative zone scope in different periods, (A) hall boundary in 1904 and city/county boundary in 2001 overlaying map; (B) fort boundary in 1904 and town/township boundary in 2001 overlaying map; (C) village boundary in 1904 and village/li boundary in 2001 overlaying map

To further prove that village area and quantity increase do affect administrative zones allocation and ifluence distinctive spatial differences in eastern mountain areas and western plains, we further arrange

analsis results from spatial overlays and landscape indices. Fig. 8 shows significantly increasing density in villages in central Taiwan from 1904 to 2001.

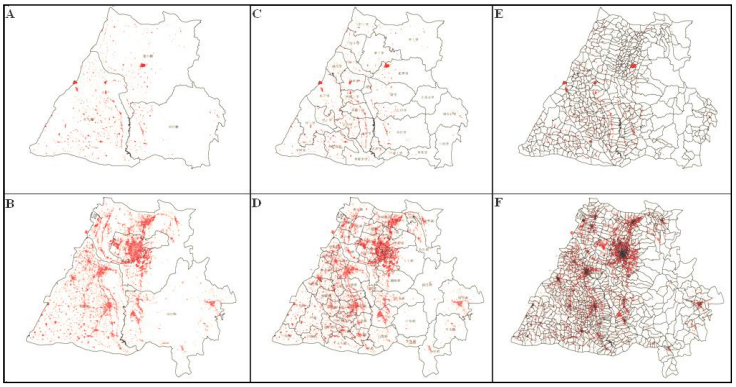

Fig.7 Comparison of administrative zone scope (black line)and village distribution(red dots) in central Taiwan, (A) hall boundary in 1904; (B) city/county boundary in 2001; (C) fort boundary in 1904; (D) town/township boundary in 2001; (E) village boundary in 1904; (F) village boundary in 2001

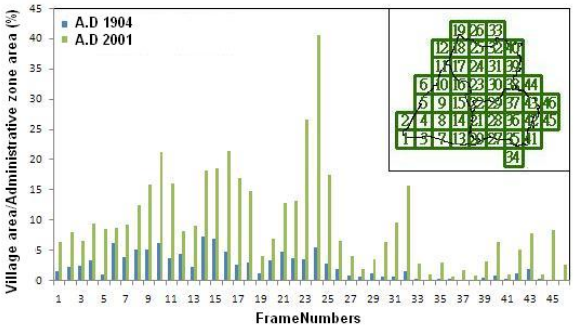

Fig. 8 Changes of percentage of villages in administrative zone area in 1904 and 2001.

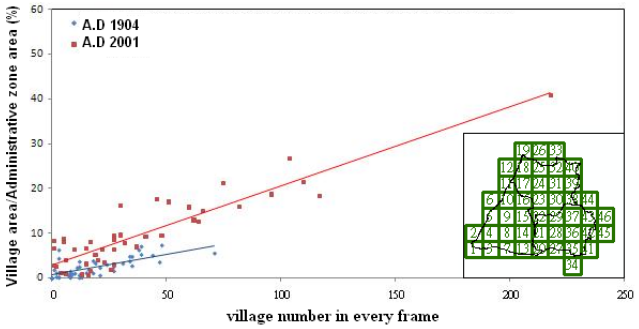

Fig. 9 Association between number of administrative zones (X axle) and average of percentage of villages in administrative zone area (Y axle) in frames Points in dotted round frames are mainly in western plains; increase ratio of administrative zones is higher.

In differences among administrative zones, in central Taiwan in 1904, Fig. 10 shows most highly developed areas of villages. The reasons to such concentration include flat terrain and a great amount of agriculture irrigated system. Agriculture development led to higher village area ratio in these areas. But the development in eastern mountain areas was significantly lower between 1% and 2%. There were

hardly any large and concentrated villages. To prevent from parties in villages and reduce tax collection differences from administrative zones, the Japanese colonial government segmented village areas into administrative zones, making concentrated villages have smaller administrative zones in homogeneous shapes. On the contrary, the administration zones were large in irregular shapes. What is interesting is, in light of village as a basic unit, village development density is in close correlation with administrative zones area (Fig. 10C, Fig. 10D).

In 2001, ratio of village area in towns/townships or villages have increased a lot to as high as over 80%. The industry focus shifted from agriculture in Japanese colonization to current commerce and industry service. With formation of major cities, village development center moved from Changhua to Taichung City as in Fig. 11. In administrative zone characteristics, concentrated village had smaller administrative zones; however, the average area of the smallest administrative zones was only 10%-40% of that in Japanese colonization, showing negative correlation between increased population and village average area. Administration zones had an average of over 80 villages/lis in places where city/county governments were.

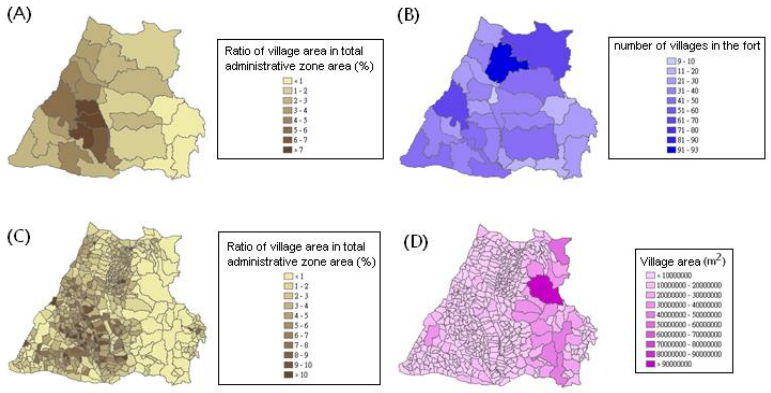

Fig. 10 Ratio of village area in total administrative zone area in 1904 (A, C) in different levels of administrative zones, number of villages in the fort (B) and village area (D)

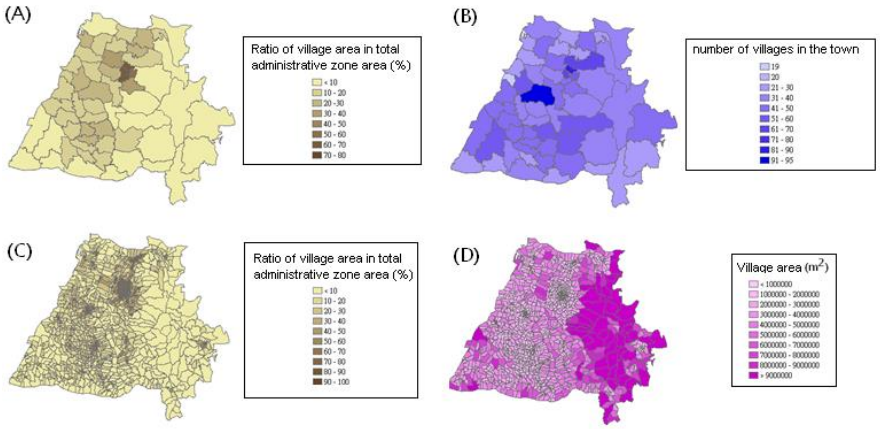

Fig. 11 Ratio of village area in total administrative zone area in 2001 (A, C) in different levels of administrative zones, number of villages in the fort (B) and village area (D)

From preceding statistics tables and layer color charts, one can find distinctive correlation between administrative zone allocation principles and (1) catchments boundary, (2) village area ratio, (3) village forms. It will be an interesting issue to whether these correlations can help predict administrative zone adjustment trend in future village expansion in different places. Take western plains and eastern mountain areas for example, change trends in the 2 places do show significant difference. In eastern mountain areas in steeper terrain, increase speed of administrative zones in each 10 km × 10 km frame is much lower than that in western plains perhaps due to traffic or not being in political/economic center, even though village area had been increased in the 100 years. Number of administrative zones in towns/townships is up to 6; that in villages/lis is no more than 50. Western plains had greater changes and differences; western plains had lower varying barriers. Due to greater regional differences and steeper terrain and stream system, administrative zones close to eastern mountain areas had more difficulty in changes. Overall, the research proves that landscape indices and mathematical models can be applied in induction and explanation of changes of administrative zones in past years. These models will help government institutes and people for urban planning personnel in adjust and allocate administrative zones in the future.

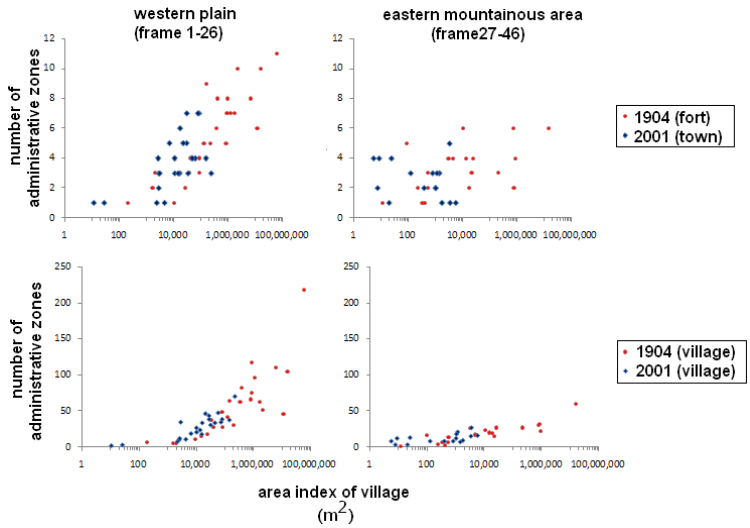

Fig. 12 Comparison of change trend of village area indices-administrative zone quantity in western plains and eastern mountain areas

Conclusions

The paper explored influence of natural and human factors on administrative zones allocation in different periods. Ideas of landscape indices analysis are introduced on geographic information system platform. The results showed homogenous landscape indices in western Taiwan due to lower terrain and concentrated development and traffic network in the 100 years, varying threshold of administrative zones in western Taiwan is lower. One can infer that this is the reason to great distinction of administrative zone adjustment in the 2 periods; in higher elevation areas of eastern Taiwan, human activities scope and locations were affected by terrain

and adjusting administrative zone allocation boundary would greatly change landscape indices, there had been no great changes in administrative zones allocation in the 100 years. The allocation mostly corresponded to and catchments boundary.Based on the analysis results, landscape indices analysis effectively presents factor ratio that affect administrative zone allocation in different regional conditions and expresses higher application of catchments division method in places with great rise and fall terrain. Under the help of the quantitative tool, qualitative methods can be made for more in-depth study.

References

Martin, D. (1991) Geographic Information systems and their Socioeconomic Applications, London:Routledge.

Openshaw, S., and Rao, L. (1995) Algorithms for reengineering 1991 Census Geography, In Environment and Planning A, 27:425-446.

Reis, R., and Raper, J. (1994) Methodologies for the design and automated generation of Postcodes from digital spatial data, EGIS. (http://spatialodyssey.ursus.maine.edu/gisweb/spatdb/egis/eg94096.html).