

Multicriteria GIS Analysis for Peri-urban Agriculture: a Case Study of Hanoi Province, Vietnam

Rajesh Bahadur THAPA
Asian Institute of Technology, Thailand
thaparb@yahoo.com

Frederic BORNE
CIRAD, France
Frederic.borne@cirad.fr

Pham Van CU
Hanoi Agriculture University, Vietnam
phamvancu@hn.vnn.vn

Abstract: The multicriteria GIS analysis model for peri-urban agriculture is a result of combined techniques of remote sensing, geographic information system and analytical hierarchical process. The model was tested on Hanoi province of Vietnam. Land use, soil, water resource, road and market were selected as major influencing parameters for peri-urban agriculture. A Landsat image of 2001 was processed to detect the land use types. Roads were extracted from topographic map of Hanoi whereas major water coverage was derived from the Landsat TM image and the market potential was sketched from Hanoi city map. The accessibility of water, road and market were further computed at different level of scale. The digital soil map of Hanoi was also used in this model. These five parameters were scaled as High, Medium, Low and Not suitable as per their strengths. The AHP method was applied for computing the priority weights of each parameter. Grid based spatial analysis was worked out using linear combination method with the corresponding parameters' weights. Finally the model is able to allocate the suitable land for the peri-urban agriculture very precisely. This model will help the peri-urban planners and decision-makers for taking action on various decisions at different levels.

Keywords: periurban, multicriteria GIS analysis, decision support system, AHP, Hanoi

1. Introduction

The challenge of supplying nutritionally adequate and safe food to city dwellers is substantial [1]. In developing countries, a substantial and growing proportion lives in or around metropolitan areas and large cities, including the zone termed the 'peri-urban', where their livelihoods depend to some extent on natural resources such as land for food, water and fuel and space for living. The peri-urban areas are heterogeneous in social composition, which is characteristic for fast changing environments [2]. Part of the reason for the observed growth in urban and peri-urban agriculture is due to its adaptability and mobility compared with rural agriculture [3]. As cities expand physically, the frontiers between urban, peri-urban and rural activity distort and merge, presenting opportunities for beneficial linkages. The peri-urban interface constitutes the habitat of a diversity of populations, including lower income groups who are particularly vulnerable to the impacts and negative externalities of both rural and urban systems [4].

The peri-urban agriculture can contribute to intensive production of perishable foods like fruits, vegetables, meat and fish, dairy products and employment opportunities generation. The urban consumers significantly consume such foods [5]. Some are consumed by the households involved in production, processing and distribution and therefore contribute directly to their food security. The peri-urban agriculture also generates formal and informal employment for farmers themselves as well as food processors and distributors. Many urban farmers, especially women are likely to use income earned from farming on food provision for the family. The urban food supply (especially fresh nutrient-rich food) increment, employment and income generation, urban environment improvement, and global food insecurity reduction are the major contributions of peri-urban agriculture [6].

The rate of urbanization in Vietnam has been increased from 15% in 1960 to 25% in 2001 and projected to be doubled (31.6%) in 2015 [7]. The speed of urban sprawl and land use change might raise many problems such as inadequate infrastructure, population and employment pressure, overcrowding, slum occurred from low income groups, fresh nutrient rich food insecurity and environmental degradation (natural and social). Hanoi city is surrounded by the agricultural activities. Therefore peri-urban agriculture needs special care for its proper management and development so

that it can contribute to the economy, environment and society. If we manage it with a business perspective then it can gear up for better production in terms of quantity as well as quality.

2. Study Area and objective

The Hanoi province was selected as a study area (Fig. 2.1). Hanoi province is located in Red River delta, the rice bowl of Vietnam after Mekong River delta. The province spread over about 928km² area with flat (0.3% slope) topography from northwest to southeast. The province comprises of seven inner urban districts and five surrounding peri-urban districts with agricultural activities [8]. Because of sunny and tropical weather along with monsoons, the climate is favorable to agricultural development in Hanoi [6]. The population of Hanoi province was 2.81 millions with 3.2% growth rate where 53.56% population were lived in urban area and the other lived in peri-urban area [7]. The competition between demand and supply of land for different activities are playing crucial role in land use morphology of Hanoi urban and peri-urban areas. Timely updated land use information and major linkage information between peri-urban and urban areas are necessary for optimum resources management. Therefore multi-criteria GIS analysis technique could be useful in peri-urban agriculture planning. The main objective of this paper is to present a GIS methodology that solves the location specific multi-criteria decision making problem of peri-urban agriculture planners.

3. Methodology

Land use, soil, water-resource, road and market as major decision making parameters for peri-urban agriculture were selected. Landsat TM image acquired on November 23, 2001, a soil and a topographic map (1:10000) and a field survey (2003) data were used as input for the study. The land use map was prepared using Landsat TM 30meter resolution image within 90% of accuracy level. The soil map was classified based on Bardy [9]. Rivers and ponds/lakes were extracted from the land use map and used as water resource parameter. Considering different level of water flow motion in rivers and ponds/lakes, the water proximities at aerial distance of 1km, 2km and 3km from rivers and 0.3km, 0.6km and 0.9km from ponds/lakes were computed. Similarly, the aerial distances of 1km, 2km and 3km from road network and 10km, 20km and 30km from market zone were assigned while computing the road and market proximity to peri-urban agriculture areas. Each parameter was further converted into 30meter grid and scaled into Very Good, Good, Fair and Unarable for peri-urban agriculture. Analytical Hierarchical Process (AHP) model [10] was used to identify the priority of the parameters. This model evaluates the consistent weight of each parameter through pair-wise comparison [11]. The priority weight within 0.1 consistency ratio is acceptable. Each parameter multiplying with their weights were linearly added and scaled into 0 to 3 as Unarable(0), Fair (1), Good (2) and Very Good (3) for peri-urban agriculture. This map can be used as a guideline while making Hanoi peri-urban agriculture planning. The urban districts were excluded while analyzing suitability of peri-urban agriculture.

4. Result and Discussion

Basically, the term 'suitability' refers to the use on a sustained basis which involves matching the capability of land in given limitations with the requirements for the peri-urban agriculture use. Five spatial decision indicators namely, Land use (Fig. 4.1), Soil (Fig. 4.2), Road (Fig. 4.3), Water (Fig. 4.4) and Market (Fig. 4.5) were used for land suitability analysis of peri-urban agriculture of Hanoi province. The land suitability assessment has been limited on five peri-urban districts. To overcome the multi-indicators with multi-properties problem, the multi-criteria decision making model need to be used where every indicators should involve as per required scale while making decision. Each decision indicator has its weight computed from AHP method. The soil is identified as the most important indicator for agriculture, which has got 37 weights. Second most important indicator is land use that is assigned a weight of 31. The other indicators, road, water resources and market got 16, 10 and 6 weights, respectively. The weights were identified for each indicator within the 0.09 coefficient of consistency ratio. All indicators with their weights were linearly combined and calculated the mean score using raster GIS.

In Hanoi peri-urban area, total 438.33 km² (52%) is found as arable land (Table 4.1). The resultant map of suitable land for peri-urban agriculture (Fig. 4.6) shows that 308.48 km² area of arable land is highly suitable, 115.36 km² is medium suitable, 14.49 km² is low suitable. The 109.67 km² area is found to be not suitable. In the highly suitable land, the coverage of 84.31km² is in the Dong Anh district alone where as the two districts namely, Soc Son and Gia Lam have similar area of 77 km² and other remaining two more districts have the area ranges from 33-36km². About 87km² area is accounted as medium suitable land for peri-urban agriculture in the Soc Son district. The Dong Anh district has only 15.30 km² of medium suitable land area. Three more districts with 2-6 km² areas are ranged under the medium suitable land. Only

14.49 km² area is under low suitable category, where almost all land falls in Soc Son district. Total 51 km² area of the Soc Son district found as not suitable land for the peri-urban agriculture. Some areas such as 20.24 km², 17.87 km², 10.48 km² and 10.08 km² of Dong Anh, Gia Lam, Tu Liem and Thanh Tri also fall in not suitable category, respectively. It may be due to the lack of fertile soil, market accessibility, water resources accessibility, etc. The areas considered as not suitable may be suitable for housing, built-up area or setting up new industrial estate and so on. Rest of the areas of peri-urban is covered either the water resources or built-up and forest cover.

Table 4.1: Land Suitability for Peri-urban Agriculture

Peri-urban District	Suitability Area (km ²)				Total Area
	High (S1)	Medium (S2)	Low (S3)	Not (N)	
Soc Son	77.71	86.97	14.22	51.01	229.91
Dong Anh	84.31	15.30	0.18	20.24	120.03
Gia Lam	77.35	5.99	0.03	17.87	101.25
Tu Liem	35.63	2.76	0.01	10.48	48.88
Thanh Tri	33.47	4.35	0.04	10.08	47.94
Peri-urban:	308.48	115.36	14.49	109.67	547.99

5. Conclusion

The multi-criteria GIS analysis has allocated the land at different scale of suitability for peri-urban agriculture in Hanoi province after prevailing intensive judgments. The study identified the level of suitability of the land, particularly for peri-urban agriculture in spatial dimensions. Therefore, the planners from Hanoi province may implement their plan in the allocated land in priority basis. Every level of suitability can be utilized for different purpose for example; the unsuitable land for peri-urban agriculture can be used for establishing the industrial estates. The low suitable zone can be checked for fish farming or cow milk farming or others species based on their requirements. While implementing the results with provincial master plan, there may be some unavoidable factors affecting the economy or society, but government may rule and convince the people to modify their way of thinking as the government directed. Finally the model is able to allocate the suitable land for the peri-urban agriculture very precisely. This model will help the peri-urban planners and decision-makers for taking action on various decisions at different levels. If the planners and decision makers of the Hanoi province follow such a model while making decision for developing peri-urban agriculture in terms of land allocation, the future urban environment would be better guided to sustainable and safer.

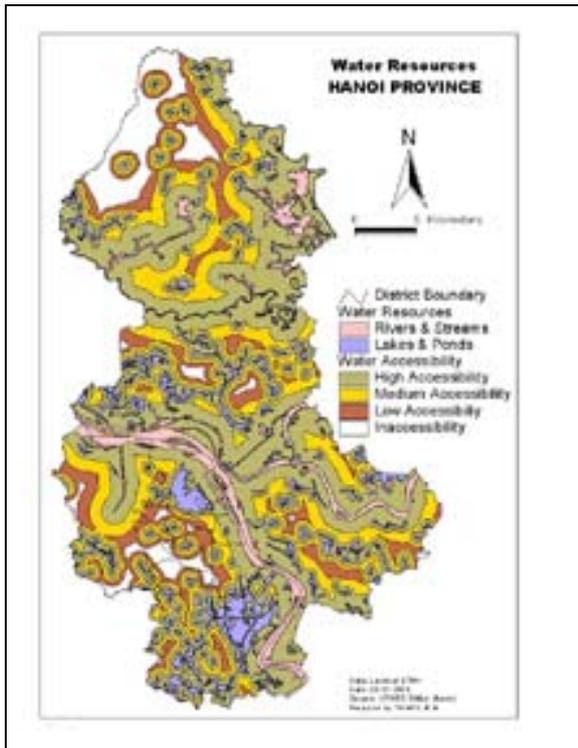


Fig. 4.4: Water Accessibility

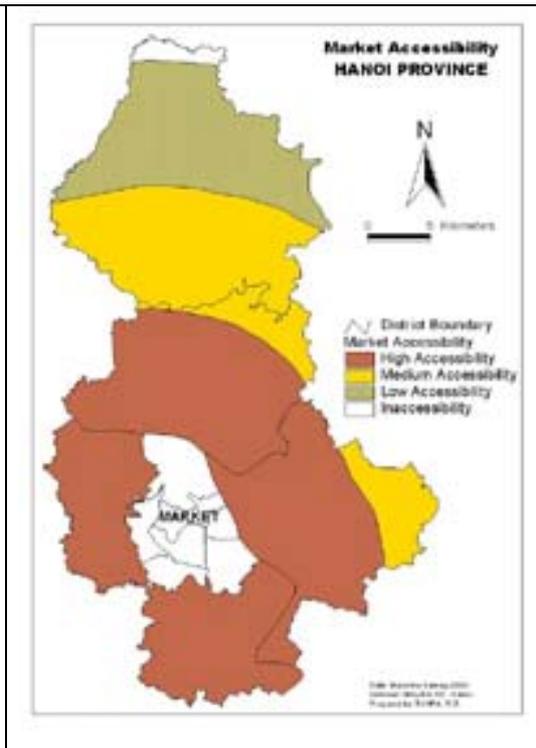


Fig. 4.5: Market Accessibility

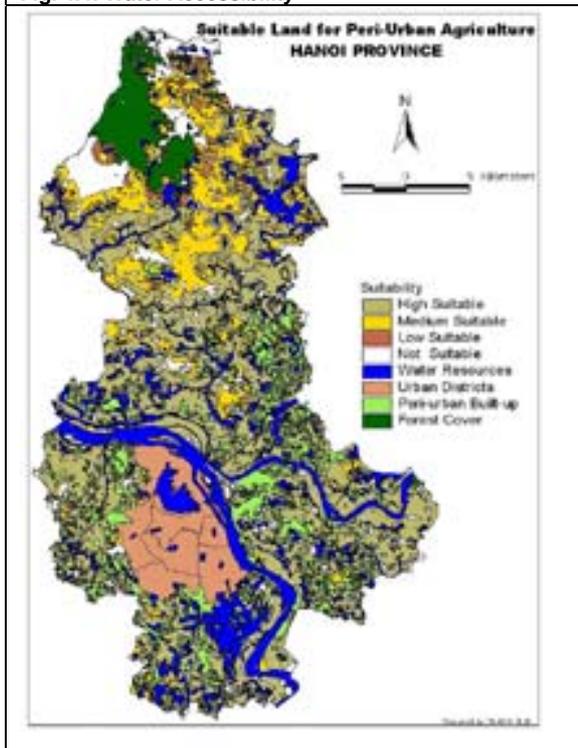


Fig. 4.6: Suitable Land for Peri-urban agriculture

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