

EVALUATION OF LAND UTILIZATION FOR REGIONAL DEVELOPMENT – A GIS APPROACH

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Abstract

In the present study, an attempt was made to develop a conceptual land use strategy for regional development in four provinces of northeast border region of Thailand. A detailed GIS analysis was done to create comprehensive database including land use, soil suitability, socio-economic data, rainfall, etc. The current land use was studied using GIS, satellite remote sensing, field observation and published records. In the current land use it was found that about 43% of the total land was used as farmland, 26% was forest and 31% was other land use. About 7% of total land was grassland, which was found barren and unused in dry season along with the 43% paddy area. The developed GIS database helped in investigating the non-uniformity in the socio-economic status in the region. It was found that the traditional agriculture practice was neither helping to upgrade the socio-economic status nor utilizing the land at its best. Only few districts were found at relatively good socio-economic status performing proper crop cultivation. Cash crops growing area secured moderate economic status but the same area was also showing comparatively high job less percentage. The relation of land use and socio-economic status showed that the land has been utilized in less productive manner. While the present farmland was underutilized, deforestation was observed for increasing the agricultural production. It is found that, a multi layer GIS analysis makes it easy to develop a framework for the optimum use of land area could increase the production yield preserving the environmental condition

Introduction

Agriculture is the backbone of the financial status in the developing nations. Agricultural productivity has always influenced the social status in most of the Asian region. It is interesting to study the land use dynamics in relation with socio-economic status of region. In many cases it is found that the farmers and landowners are following a typical culture system, which is not recommended for natural environmental conditions as well as for the best use of the land for particular purpose. Keeping the future needs in view a strategy is needed to develop which makes optimum use of land. Land use planning balances between the agriculture practice and environmental conditions, integrates the farmland and makes appropriate environmental development. For the policy makers, the problem always lies between the area to be covered and policies to be implemented. Also it is important to study the land use in relation with various factors like population, environmental conditions and available resources. All these factors contribute with varying degree to change dynamics of an area. To complicate the matter, agriculture development is impeded by limiting water availability, poor soil and severe climate, giving rise to monoculture and widespread deforestation.

Geographic Information Systems (GIS) is a vital tool to analyze a multi-layered database. Its capabilities to process various data in spatial domain make the planning process easier. A normal case is that GIS technicians process spatial data through GIS and present the results to decision makers and planners (Ren, 1997). Land use constitutes a fundamental mechanism for development and it can serve as guiding tool to direct the development efforts towards prosperity and sustainability. As the development object becomes more and more complex land use planning has to deal with complex and multidimensional interactions (UN June 1997).

Objectives

In the present study an attempt was made to investigate the relation between the land use and socio-economic status. The influence of agriculture practice on socio-economic parameters and their relation among each other was studied keeping land use map as a base map. It also focuses on the fact that the traditional agriculture practice degrades the land capability and causes deforestation. It also describes the problems and remedies while handling the multidisciplinary data covering a large area in geo-spatial environment.

Study Area

The area under study is located in northeast part of Thailand. This is area of about 26000 sq km, which is geographically located in latitude 16° 16' to 18° 06' and longitude is 103° 07' to 105° 00' in Thailand-Laos border region. The study area includes four provinces Sakon Nakhon, Nakhon Phanom, Mukdahan and Kalasin. Out of these two provinces were along Mekong River and mainly having paddy as agricultural output. The middle part of the study area is mountainous and about 20 % of the area was under forest and distinguished as National Park. The Sakon Nakhon is the biggest province of about 9400 sq km area where as smallest Mukdahan is about 4200 sq km. Other features like rainfall, elevation, and the meteorological conditions are tropical. Remotely sensed imagery of Landsat TM was acquired during October 1995 for wet season and December 1999 for dry season.

Methodology

The Project execution was done mainly in three phases of analysis to perform main actions viz. (i) Data gathering and Compilation and (ii) Analysis and Verifications.

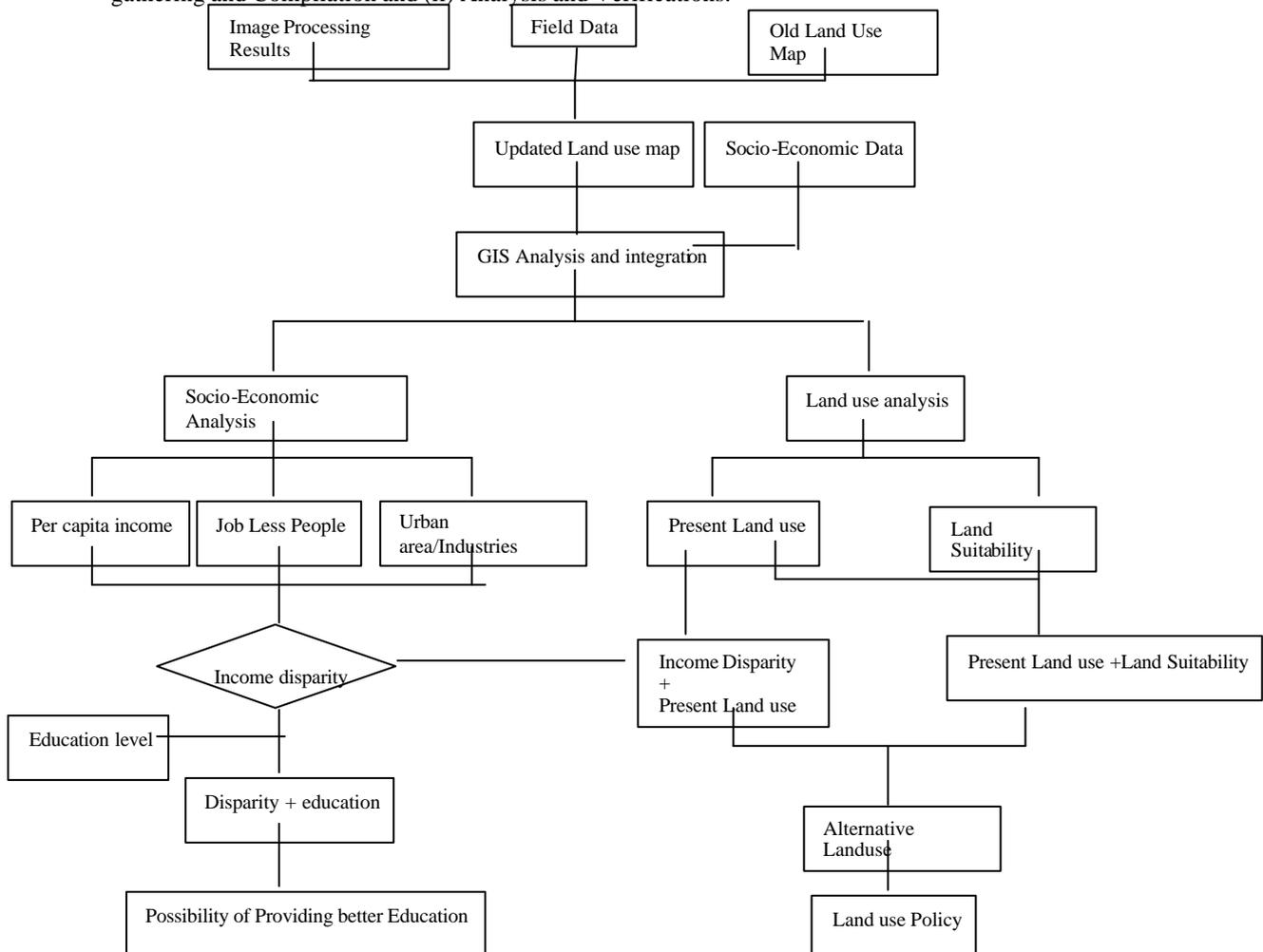


Figure 1: Data Integration in GIS

Above is the simplified flow chart of the methodology. In first step simple primary maps were prepared depending on the gathered data from various authorized agencies. The existing Land Use Map was obtained by rectifying Old Land Use by Digital Classification. Due to unsatisfactorily results of the digital image classification, the area was manually categorized in main Land Use classes on enhanced image. The final maps were obtained after validating the result by the field checks. The ground truth information was collect for about 200 points with the information about the GPS reading, existing Land Use, Spectral Signature etc. After several iterations of the field data and image processing results, a final existing Land Use map was prepared.

Using published records and documents maps for Per Capita Income was prepared in socio-economic analysis. While doing the categorization average income per household was taken under consideration and this map was taken as base map for further analysis. The map was based on the other factors like Population Density, Job less People, Urban and Industrial growth etc. The output was compared with the industrial growth and the education level as well.

Further the detailed analysis of the prepared maps was done in the third part. Several overlay combination like Soil Suitability- Land use, Soil Suitability- Rainfall, Upland Crop- Irrigation Scheme etc. were performed to study the social and financial status of the region. Considering all the influencing factors an alternative strategy for land use plan was decided for better land use policy.

Results and Discussion

Socio-Economic disparity and Land Use Analysis

As depicted in figure below there was wide discrimination in Per Capita Income, which reflects the overall situation of the state. None of the region was found developing consistently. The Income score Map was based on the income levels. It was found that about 80% of the area was having monthly income less than 50 US \$. Only few districts were found were the income lies between 100 – 200 US \$. To investigate further it was found that the Percentage of jobless people in 70 districts was more than 21% of the people of total population are jobless and in about 20 districts significant population is under poverty line. This showed that the financial growth of region is neither uniform nor satisfactorily consistent. Also very low industrial growth indicated that the major part of population rely on agriculture so it was necessary to

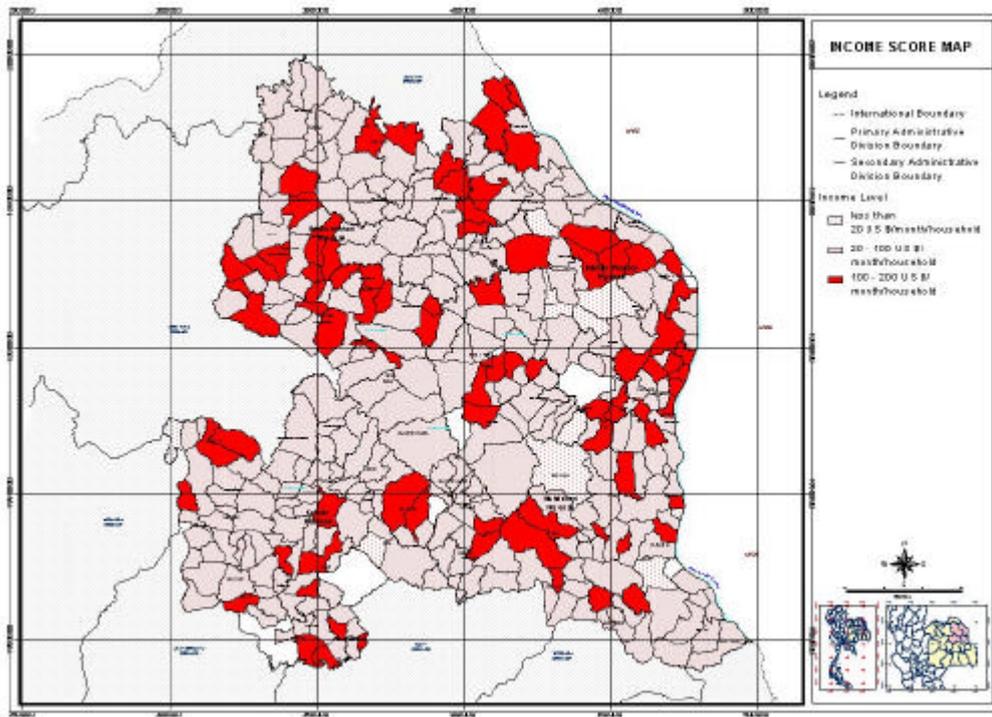


Figure 2: Income Score Map

investigate the relation between the agriculture and the resource utilization in the region.

The above analysis showed that since there was not other factor, which was not directly affecting the social status of the region the agriculture practice in terms of Land Use Map was studied and analyzed rigorously.

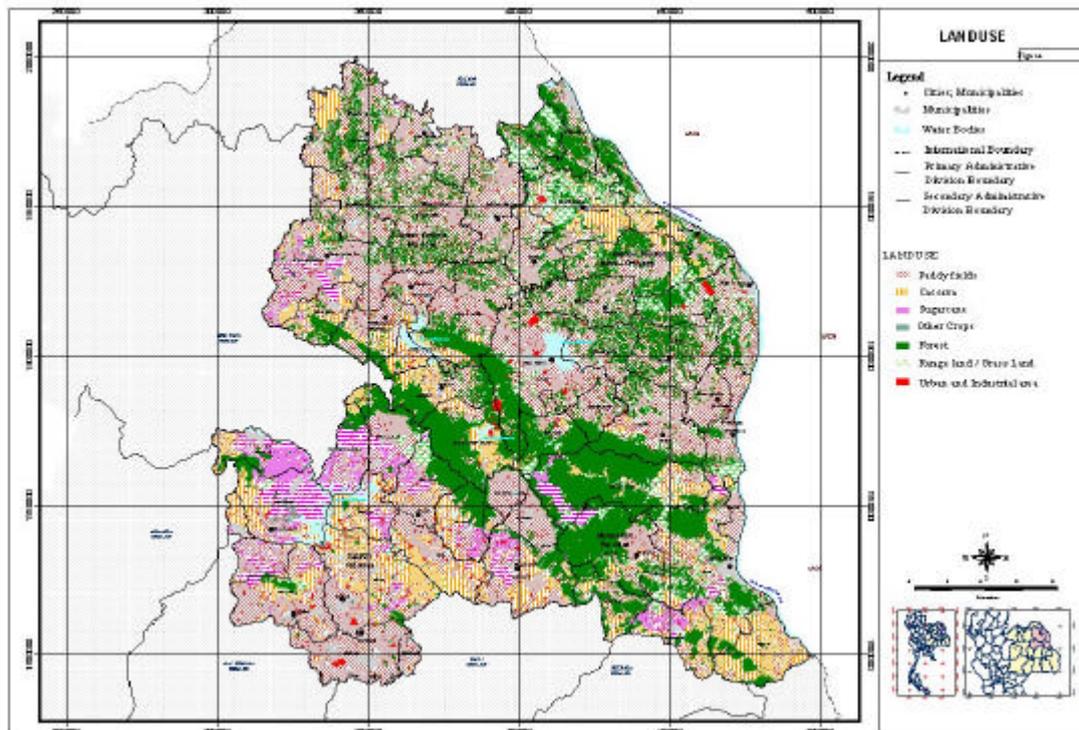


Figure 3: Land use Map

Though Paddy was major agriculture output, Upland Crops like Sugar Cane and Cassava. Following is the table showing the statistics of the land use for the complete region. Biggest paddy area was found in Sakon Nakon where the deforestation was observed prominently whereas grasslands were observed in Nakon Phanom region this could also be a result of deforestation. About 26% of the total area was under forest. Also when compared forest area was found shrunk by 27% in last 2 decades gradually increasing the barren land. Sakon Nakon province was found more prone to the deforestation about 46% of the total deforested area (6967 sq km) was found under paddy. Upland Crops like sugar cane and Cassava is majorly grown in Kalasin province. Totally 3275.12 sq km and 235.68 sq km land is under sugar cane and cassava respectively. The area for all the land use in both seasons remains almost same except the ungrown or little grown paddy in dry.

Table 1: Land Use Area Statistics (sq km)

| | Paddy | Sugar cane | Cassava | Others | Forest | Grass land | Urban | Water | Total |
|--------------|----------|------------|---------|--------|---------|------------|--------|-------|----------|
| Sakon Nakon | 4933.01 | 789.56 | 121.69 | 23.91 | 2634.52 | 419.86 | 304.07 | 113.3 | 9339.85 |
| Nakon Phanom | 2185.70 | 375.22 | 9.04 | 28.24 | 1786.98 | 797.69 | 149.62 | 147.3 | 5479.47 |
| Kalasin | 3229.45 | 1295.94 | 888.44 | 69.96 | 669.06 | 152.79 | 324.33 | 278.1 | 6908.01 |
| Mukdahan | 851.42 | 814.40 | 235.68 | 11.22 | 1802.70 | 350.32 | 71.03 | 50.64 | 4189.40 |
| Total | 11199.58 | 3275.12 | 1254.85 | 133.33 | 6892.74 | 1720.66 | 849.05 | 589.3 | 25914.67 |

When the land use map was overlaid with per capita income map it is observed that in some places in Sakon Nakon are comparatively earning better with the paddy cultivation. On the other hand richer areas were found growing cash crops in Nakon Phanom. Kalasin and Mukdahan were found at the middle level of earning with major product as Upland Crops. Cassava fields were found in both Nakon Phanom and

Mukdahan but the socio-economic status was not same. The reason behind this was found by checking the Soil Fertility in the area, the comparatively high and moderate fertile soil was mostly found in the Nakhon Phanom region.

Land Use and Land Suitability Analysis

To investigate the drawbacks in the present agricultural practice a multi-layered GIS analysis, which was mainly concentrating on the present land use and land suitability of various crops like sugar cane, cassava, rubber, fruits and vegetables etc and the natural environmental conditions. During the overlay analysis it was understood that although the crop cultivation is not all together different than the land suitability for the particular land use, the production can be increased as same land can be used in different ways to elevate the agricultural production. Like it was found that land suitability for cassava, sugarcane and fruits and vegetable is almost the same exclusive of some area in Nakhon Phanom and Sakon Nakhon border region. But at the same time that area was found under forest so considering all the factors following is the map was prepared which shows the common land suitability for Cash Crops and Rubber. As the cash crops were mainly being taken in low fertile area some disparity was examined among all the crops irrespective of the season of cultivation and the environmental conditions.

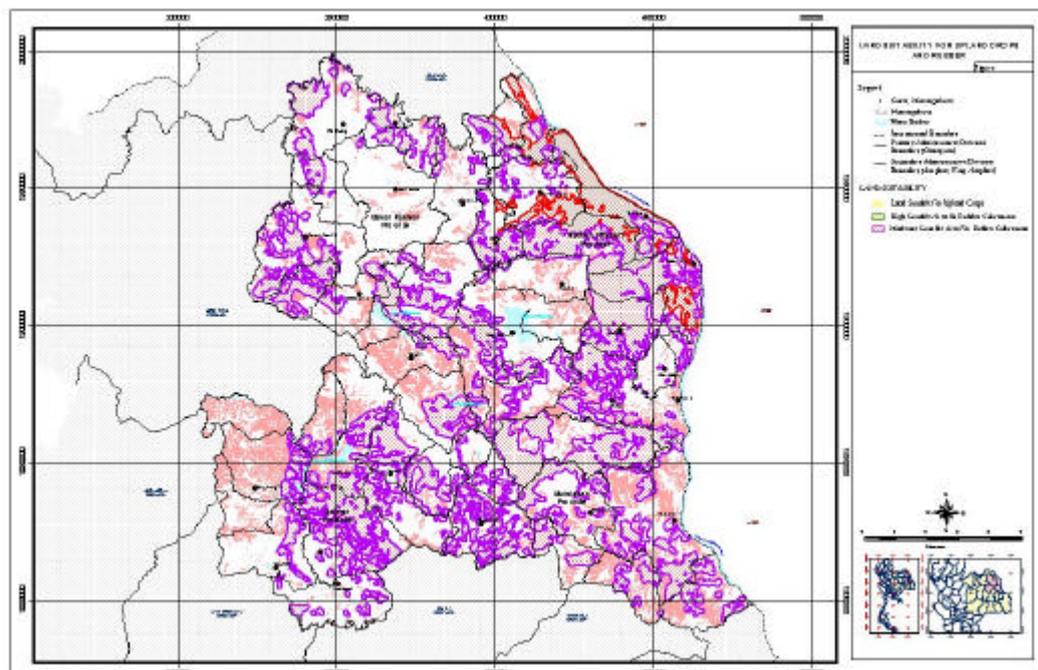


Figure 4: Land Suitability Map for Upland Crops and Rubber

Particularly grassland, which remains barren in dry season, could be used for the cultivation of upland crop like sugar cane as the land in Kalasin and Mukdahan is most suitable for such cultivation. Even growing the cassava, a difference was found in the financial status of Mukdahan province as that of Nakhon Phanom. The same area can be brought under sugar cane cultivation. The area close to the dam irrigation was found cultivating sugar cane and at richer status than the others. In many places in Nakhon Phanom and Sakon Nakhon sugar cane is found suitable as dry season crop. According to the Agricultural Statistics of Thailand the production yield of first rice (160 – 320 kg/rai) and second rice is (260 – 490 kg/rai). As the production yield of sugar cane (8290 – 8380 kg/rai) in the area was greater than the cassava (1720 – 2220 kg/rai) it is recommended to have sugar cane as a optional crop in dry season.

Above analysis showed that the land, Nakhon Phanom Province has comparatively fertile area than others but still the production yield is unimproved, which was shown as grassland or under upland crop or even under paddy was, actually was a bare land without any expected use. A major part of land Nakhon Phanom

was found the most suitable area for Rubber cultivation. The rest area was found moderately suitable and scattered over all the provinces. Especially in Nakon Phanom the other climatic conditions like rainfall is high (more than 2000 mm/year) in the region, under such condition rubber plantation can be a useful alternative instead of traditional farming.

Prospective and Constraints of GIS/RS in Land use Planning

Handling this kind of big dataset give rise to many problems during the processing. Some of those are:

For remote sensing analysis temporal data availability and crop dynamics plays a vital role, as this information is the key factor in doing the digital classification. Further the spectral signature of different object creates errors in the training sample selection and ultimately affects the results. Some times the factors like GPS accuracy, and personal judgment also make the ground truth information faulty.

In GIS side the data gathering and compilation makes the user difficult as the data structure and the statistics changes with the different agencies. Also in the projects like this expertise, other accessories like computers are needed to do the project successfully.

Conclusion and Recommendation

We can conclude that the conventional agriculture is not helping to elevate the social status of the region hence a strategical development plan is needed to prepare which can use all the resources including the manpower and the environmental condition to lead to alternative agricultural practice.

It was found that the major area was suitable for paddy but also taking advantage of other environmental factors like rainfall, soil fertility, land suitability, etc. cultivation of other upland crop can maximize the production yield. In the same manner, some region were found suitable for two crops like rubber and cassava in this case other factors are also needed to considered. The relation of land use and socio-economic status showed that the land has been utilized in less productive manner. The regions growing cash crops were found at moderate-income level even at comparatively high jobless percentage. The Jobless people could be employed by establishing rubber farms. This shows that the Socio-economic status of the region influence the agricultural practice and vice versa. While the present land was underutilized, deforestation was observed for increasing the agricultural production. A multi layer GIS analysis makes it easy to develop a framework for the optimum use of land area could increase the production yield preserving the environmental condition

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References

Fuhu, Ren., 1997. A Training Model For GIS Application in Land Resource Allocation. ISPRS Journal of Photogrammetry and Remote Sensing, 52, pp. 261 – 265

United Nations, June 1997 Guidelines and Manual a Land use Planning and Practices in Watershed Management and Disaster Reduction: Economic and Social Concerns for Asia and the Pacific.