# SOME IMPLICATIONS ON AGRICULTURAL LAND USE AFFECTED BY LAND QUALITIES IN SAKON NAKHON BASIN, NORTHEAST THAILAND.

Mongkolsawat, C., Putklang, W., and Chanket, U.

Geo-informatics Centre for Development of Northeast Thailand,
Faculty of Science, Khon Kaen University, Khon Kaen Thailand 40002

## ABSTRACT

Crop requirements are normally confined to certain land qualities which in turn reflect to land use pattern in the areas. Exploring land qualities under a given land use was conducted with objective of identifying the land quality limitations and its consequences on land use pattern. The study area, Amphoe Wanon Niwat, is located in Sakon Nakhon basin and significantly differs in land use pattern when comparing to the extensive areas in the Northeast. We used the 1995 Landsat TM and the 2002 orthophotography to identify the change of land use pattern of the areas. Evaluation of land suitability for rice, sugar-cane, cassava and rubber tree was conducted, based on the integrated land qualities concerned by using GIS. With the established GIS database, the overall insight into each land quality affecting the crops could be determined. The spatial land qualities and their associated attributes were used to analyze the causes and their consequences on land use patterns. Our work demonstrates that an analysis of satellite data and aerial orthophoto can provide detailed, spatially explicit identification of land qualities causing the consequent agricultural land use pattern in the Sakon Nakhon Basin. The shallow lateritic soils, improper land use and mis-management of land have significantly caused the current land use patterns with relatively low agricultural productivity.

**KEYWORDS:** Land use, Land quality, GIS, Lateritic soils, Sakon Nakhon Basin

## 1. INTRODUCTION

Northeast Thailand or Korat Plateau is a large, saucer-shape basin with the prominent raised margins to the west, south, southeast and east. Phu Phan mountain range lies in a northeast-southeast direction dividing the plateau into two basins, the larger Korat basin to the south and the smaller Sakon Nakhon basin (SNKB) to the North (Mongkolsawat, et al, 2006). The two basins are underlain by the same geologic Formation namely Maha Sarakham which was formed by a thick sequence of Mesozoic rocks, ranging in age from Tertiary to Cretaceous. Distinction in amount of rainfall between the two basins is evident, mean annual rainfall is 1,200 m.m in the Korat basin and 1,600 m.m in the SNKB. Nevertheless the higher rainfall in the SNKB, the rice yields in the SNKB are generally lower than those of the Korat basin (Sakon Nakhon Rice Research Center, 2010). Moreover, the major parts of the SNKB land areas are unproductive with a limitation of the suitable area for economic crops when compared to those of the Korat basin. Agriculture is the major occupation of over 75% of the population and average household income for the area is 25,642 THB (The Sakon Nakhon Provincial Office, 2010). The majority of farmers in the SKNB own different land-type both paddy land and upland fields as well they utilize these land type for rice production whatever reasons, leaving the parts of land where insufficient water idle. The land use patterns in the SKNB are mostly confined to rice paddy, degraded Dipterocarp forest and rangeland. The land use for economic crops (cassava, sugarcane and rubber tree) is rarely seen, the causes of this constraint should be investigated. Performing land use/land cover (LCLUC) changes in together with land suitability evaluation is therefore identified to determine land qualities limitations. Multi-temporal satellite data are widely accepted to map LCLUC under which we can search for land qualities by using GIS. The study thus aims to identify the land quality limitations and its consequences on land use pattern.

## 2. STUDY AREA

The study area Amphoe Wanon Niwat, a part of Sakon Na Khon province, is lacated in the SKNB and covers an area of about 1001 sq.km (Fig.1). Physiographically, the areas are flat to gently undulating terrain with elevation of about 170 m. above mean sea level. Land use pattern in the areas is dominated by human milieux over which are rice based for subsistence and dwarf dry Dipterocarp forest with its fragmentation.

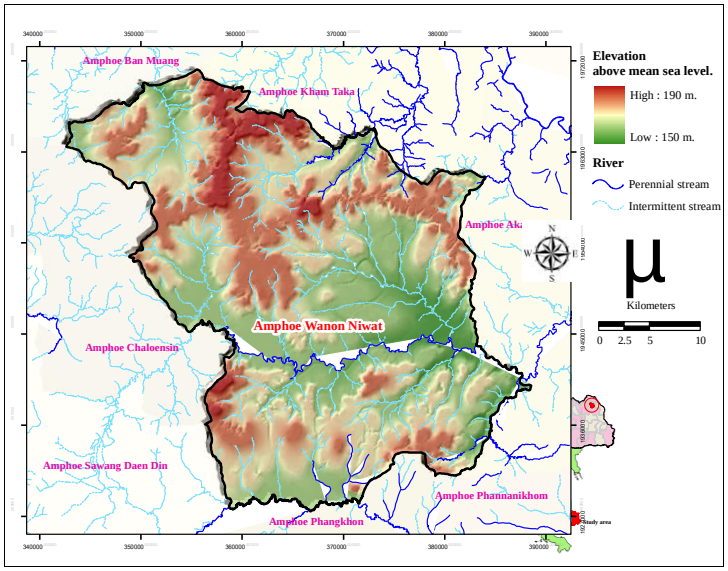


**Figure 1.** Study area

## 3. MATERIALS AND METHODS

The procedures in this study consisted of LCLUC change identification using multi-temporal remotely sensed data and integrated analysis of land qualities for economic crops. The results to be obtained could be used to determine land quality limitations for the economic crops and consequences.

### 3.1. Data sources

**Remotely sensed data**

Landsat TM Data 30 m. resolution acquired on December 1995

Aerial orthophoto registered in the UTM, WGS84, scale 1:4,000 acquired on 2002

**GIS data layers**

| GIS data layers and their associated attributes | Scale | Year | Source |
|---|---|---|---|
| Administrative Boundary | 1:50,000 | 2005 | GECNET |
| Soil series group | 1:50,000 | 1995 | LDD |
| Landform | 1:50,000 | 2003 | GECNET |
| Land suitability for rice | 1:50,000 | 2008 | GECNET |
| Land suitability for sugarcane | 1:50,000 | 2008 | GECNET |
| Land suitability for cassava | 1:50,000 | 2008 | GECNET |
| Land suitability for rubber tree | 1:50,000 | 2008 | GECNET |
| Land suitability for grazing | 1:50,000 | 2010 | GECNET |

GECNET = Geo-Informatics Centre for the Development of Northeast Thailand.
LDD = Land Development Department.

### 3.2. Image preprocessing

The Landsat TM data of 1995 scenes were executed geometric correction, transforming the image coordinates to the orthophoto and performing a resampling of the pixel with the nearest neighbor algorithm.

### 3.3. Identification of land use pattern

On screen digitization of the remotely sensed data was performed to identify land use in 1995 and 2002. GIS data layers for 1995 and 2002 land uses were established, based on UTM/WGS84 coordinate. The obtained map results were checked against the ground truth with over 11 ground sites of 3 replications. Observation records at each site included cover type and composition, topography, landform and related land characteristics. Allocation of the sites was based on GPS, topographic maps and satellite image. Revision of the land use map was performed to ensure the results. Land use change between the years 1995 to 2002 was then analyzed to understand the historical change patterns of the land.

### 3.4. Land suitability evaluation

Rice, cassava, sugar-cane, rubber tree and grazing that have planted extensively in the Northeast were selected for the evaluation. The land suitability evaluation was based on the method as described by the FAO guidelines (FAO, 1983). The crop requirements in terms of land qualities to be used in the evaluation process

were previously reviewed (Sys et al., 1993; LDD, 1996; FAO, 1983; Mongkolsawat, 1997; Paiboonsak et al., 2004a, 2004b). Some of the FAO defined land qualities that yielded negligible difference within the area were excluded from the evaluation. The land qualities used in this evaluation included water availability (W), Soil (S), Salt Hazard (Sa) and Terrain (T). The suitability evaluation is based on the equation: Suitability = W x S x Sa x T with the detailed definitions (Mongkolawat et al, 2007, 2009a, 2009b, 2010)

### 3.5. Analysis of the land suitability over the current land use

The analysis was digitally performed, based on the established the layers of the land suitability and the 2002 land use, using GIS. As a result, spatial matching the land use with their suitability could be determined, addressing land qualities limiting the certain land use types.

## 4. RESULTS AND DISCUSSIONS

### 4.1. Land cover/ land use changes (LCLUC)

As regards our study on the land use changes, the objective was to overview the economic crop continuum over the time. The results, based on the data acquired in the 1995, and 2002 indicate that over 95% of the areas are confined to rice paddy and degraded dipterocarp vegetations. Table 1 provides the extent areas of land use in $km^2$, their percentages and changes. People in the areas have been mostly engaged in rice paddy, representing over 50% of the total areas. The major forest in the study areas is dwarf dipterocarp forest, mostly degraded, and comprises vegetation types tolerant to drought found on the skeletal and shallow soils.

Land use maps in 1995 and 2002 show spatial distribution of land use by type, providing a comparison of the two years (Fig.2). It should be noted that no new crops are introduced to cultivate in this region, certain land qualities are likely to be the constraints. Further analysis of the constrained land qualities is investigated to understand the limitations

**Table 1** LCLUC year 1995-2002

| Land use type | Year 1995 | | Year 2002 | | Land use change | |
|---|---|---|---|---|---|---|
| | Area (Km2) | % | Area (Km2) | % | Area (Km2) | % |
| Paddy field | 734.21 | 73.35 | 548.67 | 54.81 | -185.54 | -18.54 |
| Field crops | 0.93 | 0.09 | 44.60 | 4.46 | +43.67 | 4.36 |
| Forest | 228.22 | 22.80 | 308.59 | 30.83 | +80.37 | 8.03 |
| Range land | 1.80 | 0.18 | 35.72 | 3.57 | +33.92 | 3.39 |
| Urban | 24.27 | 2.42 | 24.86 | 2.48 | +0.59 | 0.06 |
| Water body | 11.24 | 1.12 | 36.59 | 3.66 | +25.35 | 2.53 |
| Other | 0.33 | 0.03 | 1.96 | 0.20 | +1.63 | 0.16 |
| **Total** | **1,001.00** | **100.00** | **1,001.00** | **100.00** | | |

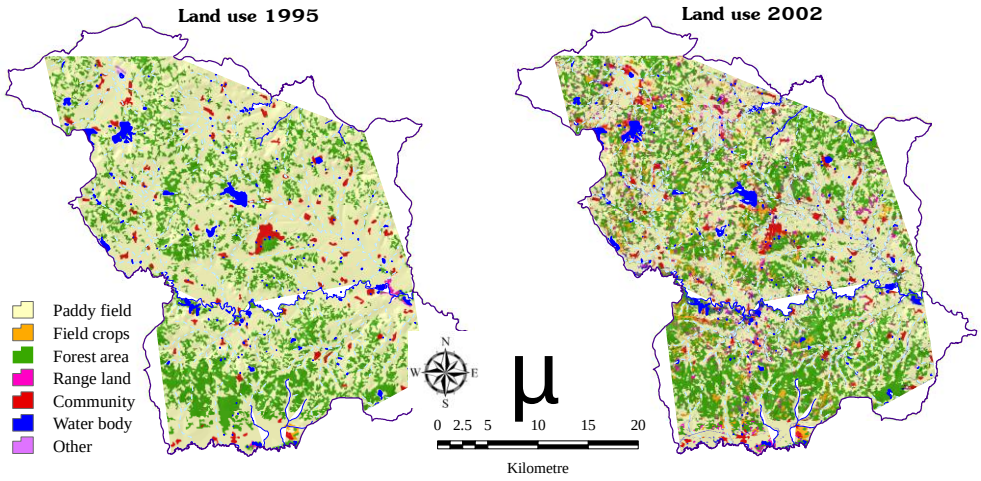


**Figure 2.** Land use 1995 and 2002

### 4.2. Land suitability in the Study area

The suitability maps resulting from the spatial overlay of the land qualities for rice sugar-cane, cassava, rubber tree and grazing are show in Fig. 3. The suitability area in addition to the spatial information of crop is shown in table 2. The marginal and not suitability lands for rice, sugar-cane, cassava, rubber tree and grazing

cover the areas of about 82.40, 89.31, 89.03, 89.31 and 41.60% respectively. The suitability lands are evident for rice and grazing which extend larger areas most of which are crops having shallow root system. The dwarf native vegetation with intermittent lateritic outcrops occurring across large portions of the areas could be observed from the ground investigation. The vegetation or degraded forest is strongly related to soil properties and depth, which are used in the land evaluation.

The land evaluation process provides the limitation of land qualities that affect apparently the suitability for crops. We found that the lateritic soils (Phen and Phon Phisai soil series) extending over 75% are the limitation of economic crop for land use. Table 3 shows relationship between soil series and current land use as a result of overlay analysis. The obtained results indicate the limitations and its consequences on land use pattern. The crops with deep root system are not capable to cultivate in this region. It is therefore recommended that rice and grazing at some extent, can be developed in the areas. Due to less soil mass, the soil physical and chemical properties are of great limitations for agricultural development, intensive research should be placed on the pasture development in terms of sustainable development.

**Table 2.** Land suitability for crops

| Class | Rice | | Sugar-cane | | Cassava | | Rubber tree | | Grazing | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $Km^2$ | % | $Km^2$ | % | $Km^2$ | % | $Km^2$ | % | $Km^2$ | % |
| High suitability | 51.88 | 5.18 | 47.49 | 4.74 | 26.36 | 2.63 | 46.52 | 4.65 | 449.25 | 44.88 |
| Moderately suitability | 68.32 | 6.82 | 3.63 | 0.36 | 27.50 | 2.75 | 4.56 | 0.46 | 84.82 | 8.47 |
| Marginal suitability | 797.01 | 79.62 | 481.29 | 48.08 | 483.20 | 48.27 | 110.60 | 11.05 | 383.28 | 38.29 |
| Not suitability | 27.86 | 2.78 | 412.67 | 41.23 | 408.02 | 40.76 | 783.38 | 78.26 | 27.71 | 2.77 |
| Forest area | 32.39 | 3.24 | 32.39 | 3.24 | 32.39 | 3.24 | 32.39 | 3.24 | 32.39 | 3.24 |
| Community | 13.00 | 1.30 | 13.00 | 1.30 | 13.00 | 1.30 | 13.00 | 1.30 | 13.00 | 1.30 |
| Water body | 10.55 | 1.05 | 10.54 | 1.05 | 10.54 | 1.05 | 10.55 | 1.05 | 10.55 | 1.05 |
| **Total** | **1,001.00** | **100.00** | **1,001.00** | **100.00** | **1,001.00** | **100.00** | **1,001.00** | **100.00** | **1,001.00** | **100.00** |

**Table 3.** Relationship between soil series and current land use

| Soil series | Current land use (%) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ri | Up | Tr | Oa | Aq | Fo | Fo1 | Id | Ot | Ot1 | Wa | Wa1 |
| Pn/Pp | 53.85 | 64.10 | 64.81 | 36.12 | 35.92 | 72.29 | 56.01 | 62.96 | 47.33 | 60.94 | 50.41 | 50.41 |
| Pn | 18.79 | 15.70 | 14.69 | 15.19 | 15.18 | 14.19 | 17.61 | 13.66 | 15.88 | 10.43 | 12.71 | 12.71 |
| Re | 11.14 | 5.95 | 6.69 | 21.78 | 21.44 | 2.38 | 7.66 | 7.64 | 19.65 | 9.69 | 10.96 | 10.96 |
| Pp | 3.25 | 3.51 | 4.94 | 7.75 | 2.90 | 3.77 | 2.97 | 1.86 | 7.31 | 6.85 | 2.94 | 2.94 |
| Other | 12.97 | 10.75 | 8.87 | 19.16 | 24.57 | 7.37 | 15.76 | 13.89 | 9.82 | 13.30 | 22.99 | 22.99 |
| **Total** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** |

* Soil series: Pn/Pp = Phen and Phon Phisai series, Pn = Phen series, Re = Roi-et series, Pp = Phon Phisai series
* Land Use : Ri = Paddy field, Up = Field crops, Tr = Perennial tree crops, Oa = Other agricultural, Aq = Fish ponds, Fo = Forest area, Fo1 = Riparian forest, Id = Range land, Ot = Community, Ot1 = Road, Wa = Water body, Wa1 = Irrigation canal

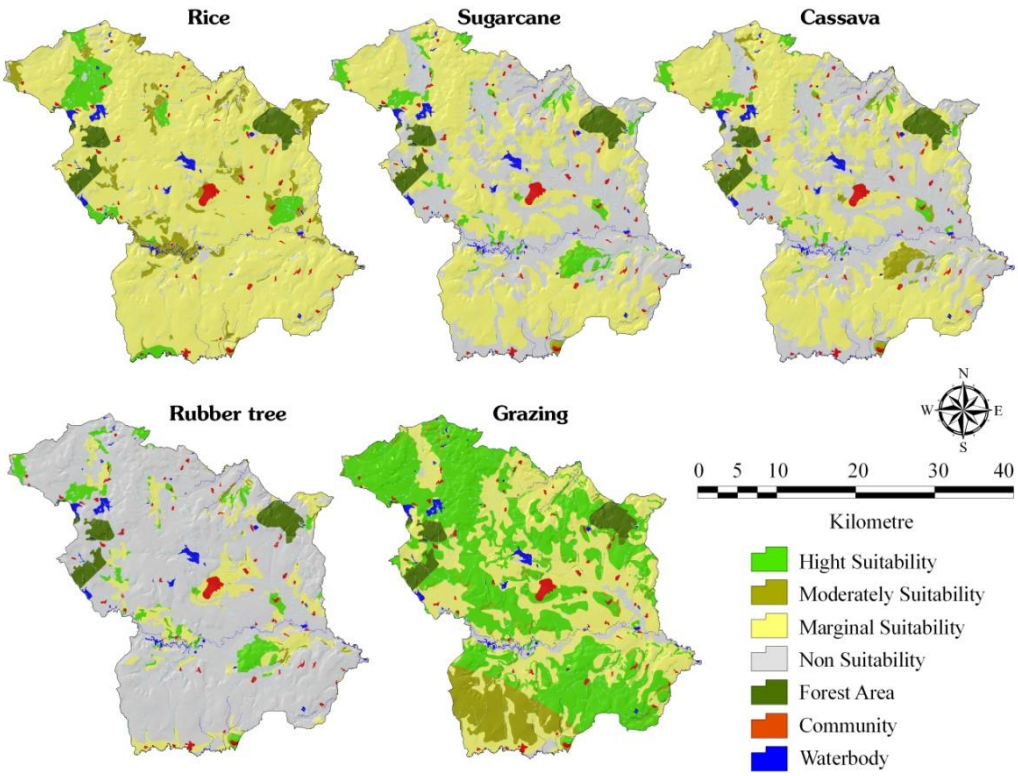


**Figure 3.** Land suitability maps

## 5. CONCLUSIONS

In general the developed methodology proved useful to identify land quality limitation and its consequences on land use pattern. Multi-temporal land use provided the consistent pattern of land use over the time period. With the land suitability evaluation, we can identify certain land qualities limiting the crop cultivation. Alternative in the area development could be made, based on the limiting land qualities obtained from the analysis. Conceptually, the areas should be kept under native vegetation with minimum disturbance of the land. Grazing over the native vegetation areas with supplement of leguminous species should be developed with minimum tillage in order to unexpose underlying soil to the area.

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