# FOREST LAND ASSESSMENT OF KHON KAEN AND MAHASARAKAM PROVINCES

## การประเมินหาพื้นที่ป่าไม้ของจังหวัดขอนแก่นและมหาสารคาม

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## บทคัดย่อ

    การศึกษาและประเมินผลการใช้ที่ดินของจังหวัดขอนแก่น และมหาสารคาม  การดำเนินการ ได้ใช้ภาพถ่ายจากดาวเทียม ขาว-ดำ แบนด์ ๔ และ ๗ มาตราส่วน ๑ : ๒๕๐,๐๐๐ ซึ่งถ่ายทำเมื่อ – ปี พ.ศ. ๒๕๑๖ และ ๒๕๒๒ และใช้ฟิล์มสีผสมบริเวณเดียวกัน มาตราส่วน ๑ : ๑,๐๐๐,๐๐๐ เป็นพื้นฐาน ในการจำแนกประเภทการใช้ที่ดินในปัจจุบันเปรียบเทียบการเปลี่ยนแปลงของการใช้ที่ดิน เพื่อจัดทำแผนที่ การใช้ที่ดิน  แผนที่การเปลี่ยนแปลงและแผนที่แหล่งที่จะมีศักยภาพในการพัฒนาแหล่งน้ำขนาดเล็ก ซึ่งเมื่อทำ แผนที่สำเร็จแล้วได้มีการออกสำรวจทางภาคพื้นดินในขอบเขตของทั้งสองจังหวัดเพื่อตรวจสอบและแก้ไขข้อ ผิดพลาด

    การศึกษาพบว่าสามารถแยกรูปแบบการใช้ที่ดินได้ เป็นที่อยู่อาศัย  พื้นที่เกษตรกรรม ซึ่งแยก เป็นนาข้าวและนาผสมป่าไม้  พื้นที่ป่าไม้ซึ่งประกอบด้วยป่าดิบแล้ง ป่าเบญจพรรณ ป่าเต็งรัง และไร่เลื่อน ลอย  นอกจากนี้ยังจำแนกแหล่งน้ำได้ เป็นเขื่อนเก็บน้ำและแหล่งน้ำธรรมชาติ  การศึกษายังค้นคว้าถึง ปริมาณผลผลิตไม้ซุง, มวลชีวภาพ, ปริมาณไม้ฟืน, และยังพบว่าพื้นที่ป่าไม้ของจังหวัดขอนแก่นลดลงร้อยละ ๑๖.๒๘ ต่อปี จังหวัดมหาสารคามลดลงร้อยละ ๑๑.๑๑ ต่อปี  และยังประเมินหาพื้นที่ถือครองทางเกษตรที่ ถูกต้องตามกฎหมายได้โดยใช้แผนที่พื้นป่าสงวนมาพิจารณาประกอบ

    การศึกษาเกี่ยวกับความเป็นไปได้ในการส่งเสริมและพัฒนาทุ่งหญ้าสำหรับเลี้ยงสัตว์ พบว่ามี พื้นที่ชายเขา-และเนินสูงที่ควรส่งเสริมเป็นทุ่งหญ้าเลี้ยงปศุสัตว์ ในจังหวัดขอนแก่น ๒๔๖,๓๖๔ เฮคแตร์ (๒๔.๑๒%)

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ส่วนในจังหวัดมหาสารคามพื้นที่ที่สมควรส่งเสริมการเลี้ยงปศุสัตว์ มีพื้นที่ทั้งหมด ๑๒๕,๑๙๒ เอคเนคร์ (๒๑.๖๕%)

ผลการศึกษาความอุดมสมบูรณ์ของดิน พบว่าคุณลักษณะดินในทั้งสองจังหวัดในพื้นที่การเกษตร มีปริมาณก้อนกรวดน้อย มีปริมาณน้ำหนัก/ปริมาตรมากกว่าดินในพื้นที่ป่าไม้ และมีความพรุนน้อยกว่าดินป่าไม้ เมื่อพิจารณาคุณสมบัติทางเคมีพบว่าดินในพื้นที่ทำการเกษตรมีปริมาณอินทรีย์วัตถุ ไนโตรเจน ฟอสฟอรัส โปแตสเซียม และแมกนีเซียมน้อยกว่าดินในพื้นที่ป่าไม้

การศึกษาความเป็นไปได้ในการพัฒนาแหล่งน้ำขนาดเล็กพบว่ามีพื้นที่และแหล่งที่เหมาะสม และมีศักยภาพพอที่จะพัฒนาจัดสร้างแหล่งน้ำขนาดเล็ก คือ ฝายเก็บน้ำ ๗ แห่ง บ่อน้ำลึก ๔ แห่ง

## ABSTRACT

A study of forest land assessment of Khon Kaen and Mahasarakam provinces is made utilizing black and white LANDSAT MSS band 5 and 7, 1 : 250,000 scale taken in 1979.

Khon Kaen and Mahasarakam provinces are classified into the urban and built-up land, two types of agricultural lands, namely, paddy field, and field crops mixed with trees or farm forest, four types of forest lands; dry evergreen forest, mixed deciduous forest, dry dipterocarp forest, and swidden areas, two types of water resources; reservoir or man-made water resources and natural lakes and ponds.

Evidence from the forest inventory revealed that in Khon Kaen forested area of 256,364 ha. having, the total saw timber merchantable volume of dry evergreen forest is 1,303,136 $m^3$ (67.52 $m^3$/ha) and the total dry weight biomass of 1,331,711.58 tons (69 tons/ha). The total fuel wood that can be exploited from this forest type is 386,386 $m^3$ (20.02 $m^3$/ha). Mixed deciduous forest has the total merchantable volume of saw timber about 1,390,548 $m^3$ (34.17 $m^3$/ha), and the total dry weight biomass of 2,005,398.32 tons (49.28 tons/ha). The total fuel wood is 3,634.877 $m^3$ (in this forest type. Dry dipterocarp forest has the total merchantable volume of daw timber 164,986 $m^3$ (5.62 $m^3$/ha), whereas the total dry weight biomass is 661,800.72 tons (22.54 tons/ha). The total fuel wood can be harvested from this type of forest is 1,223,606 $m^3$ (41.68 $m^3$/ha).

In the farm forest the average merchantable volume is about 17.55 $m^3$/ha, whereas the average fuel wood of 18.86 $m^3$/ha, and the average dry weight biomass of 14.47 tons/ha.

The comparison of land use between 1973 and 1979 of Khon Kaen province indicated that a total of 377,307 ha or 35.49 percent of the total forest land was disappeared during the past 6 years. The depletion rate is 16.28 percent per annum. This forest land was transformed into agricultural land of 371,503 ha (34.95 %). The increasing rate of the agricultural land is 10.40 percent per annum, whereas 600 ha of forest land was transformed into urban and built-up land (3.09%), and 5,204 ha transformed into water resources (2.79%).

The gross change of forest land use of Mahasarakam province between 1973 and 1979 is 111,404 ha or 19.26 percent. The depletion rate is 11.19 percent per annum. The forest land of this province are transformed into urban and built-up land of 300 ha (2.99% per annum), 110,524 ha into agricultural lands (4.61% per annum), and 580 ha into water resources (3.19% per anuum).

Findings show that the total agricultural lands of Khon Kaen province is 769,833 ha (72.42% of the total area), out of this 661,728 ha (62.25%) are classified as legal occupation, and 108,105 ha (10.17%) are illegal encroachment. Mahasarakam agricultural land covers the area of 448,128 ha (77.48% of the total area); 426,389 ha (73.72%) of this areas are as legal occupation while the rest of 21,739 ha (3.76%) are of illegal encroachment.

According to the land use classification and field observation, the total of 381,556 ha (45.76%) of upland forests having potential for rangeland development and livestock raising.

In regard to soil chemical properties, the agricultural lands of the two provinces are poor in organic matter, nitrogen, phosphorus, potassium, and magnesium contents which substitute the major element of soil chemical properties as compared to the forest lands through soil reaction (pH) suggests the comparatively strong acidity.

A study of small scale reservoir potential was conducted over Khon Kaen and Mahasarakam provinces. Characteristics of the catchment areas and hydrological data were determined. Evident from the study shows that the recommended small scale reservoir potential sites of Khon Kaen province are K1 and K6 of Amphoe Nam Pong for shallow well, K2, K5 and K8 for village tank, and K7 for deep well; whereas at Mahasarakam province the recommended small scale reservoir potential sites are M3 and M6 for village tank, M1, M5 and M7 for deep well.

## BACKGROUND

## Description of the Study Area

### Geography

Khon Kaen and Mahasarakam provinces situated between $15^{\circ}30'$ to $17^{\circ}$ North latitudes and $101^{\circ}45'$ to $103^{\circ}30'$ with varied slope from flat to steep . Khon Kaen covers the area of 13,404 $km^2$ and comprises of 14 districts namely, Amphoe Muang, Banpai, Chonnabot, Manjakiri, Phon, Khaosuankwang, Nong Song Hong, Nong Rua, Phu Wieng, Chumpae, Srichomphu, Nam Pong, Kranual, and Ban Fang. Mahasarakam covers the area of 5,760 $km^2$. The landscape is mostly flat. It includes 8 amphoes, namely Amphoe Muang, Chiengyuen, Kantarawichai, Kosoompisai, Borabue, Nachuak, Phayakkaphumpisai, and Wapipathum.

### Geology

The two types of bedrocks, usually found all over the area are sedimentary and metamorphic rocks. It also can be classified into 4 formations. First, the Salt and Khok Kruat Formation, Khorat Group formed in the Cretaceous period and consist of sandstone, shale and siltstone, with rock salt 800 feet and gypsum up to 50 feet of salt formation. Second, the Phu Kradung Formation are the Korat Group formed in the Jurassic and Triassic periods. It is mostly dark brown grayish brown, red micaceous shale with some siltstone micaceous sandstone and conglomerate. Third is Phu Phan and Phra Wihan Formation, also Khorat Group and formed in Jurassic period. It's generally consist of yellowish

gray to grayish pink massive sandstone and conglomerate and grayish red to olive gray to white massive sandstone with dark reddish brown micaceous shale and grayish red micaceous siltstone. The last are found in a narrow track along the rivers, usually known as alluvium, eluvium, valleyfill and river gravel which formed in Quarternary to recent period.

## Soils

General soil types on hills, mountains and plateaus in the west are mainly shallow Red-Yellow Podzolic Soils and Red Brown Earths. The main types in central area are poorly to well drained soils, mostly loamy and sandy soils with moderate to low fertility. This group consists of Low-Humic Grey Soils and Grey Podzolic Soils. The poorly drained clayey soils with high to moderate fertility are alluvial soils which easily found nearby the rivers and plain (RTSD, 1972).

## Climate

Climatological data of Khon Kaen and Mahasarakam can also reference to the climatological data for the period 1951-1970 which compiled from Khon Kaen climatic station. The average temperature is about $27.1^{\circ}C$ and the mean maximum and mean minimum temperatures are $32.7^{\circ}C$ and $21.6^{\circ}C$, respectively. The mean relative humidity obtained from wet and dry bulb thermometers is about 71.1%. Evaporation is measured in millimetre by evaporation pan and Piche evaporimeter is 2,182 and 1,184 mm, respectively. The range of wind velocity in Knots is between 3.1 and 4.6. The rainfall data obtained from cylindrical rain gauge give the maximum rainfall in September of 141.6 mm and minimum rainfall in December of 8.3 mm. The average rainfall is about 1,198 mm (Climatology Division, 1972).

## Vegetation

Generally, the vegetation of the study area can be defined into 3 types.

1. The Dry Evergreen Forests. This type of forests covers the mountainous land and the valleys of low hill, usually more than 500 m elevation. The composition of the forest consist of various generations,

dense, and composed of different species. In general, it composes of three storeys, the upper storey, the middle storey, and the undergrowth. About 30% of stand are deciduous species.

2. The Mixed Deciduous Forest. This forest ecotype can be classified into two sub-type as moist and dry sub-type. Both of them are composed of shedding species, about 90% of the stands. The height of predominant trees is comparatively lower than that of the Dry-evergreen forest. This type of forests occupies the area between the elevation of 300-600 m from mean sea level. It is composed of three layers in the profile.

3. The Dry Deciduous Dipterocarp Forest. This forest type dominates in the area between the elevation of 200-500 m, where the soils is either sandly or lateritic, and subjected to extremly leaching, erosion, and annual burning. The forest is rather opened and can be defined into two storeys in profile.

Farm Forest, as referred to the report of Wacharakitti et al. (1979), the term "farm forest" means a forest community with scattered standing trees left on permanent farms or paddy fields.

## METHODS

### Land-Use Classification

Land-use classification was performed on the band 5 and 7 LANDSAT black and white imageries of 1 : 250,000 scale which were recorded in 1979. The objects or land use types recognition interpretation are based on the spectral reflectance characteristics of each land-use type appear on the image. Spectral characteristics in term of color-tone and color-type differences which is primarily depended upon each wavelength are used for object recognition.

### Field Data Collection

The field data collection and ground checking were carried out in each land-use categories. The field data collection is focus on forest

inventory, water resource development potential, soil and rangeland
potential.

1. Forest inventory

An optimum allocation technique was applied to allocate and
distribute sample plot in each forest type. A forest inventory was carried
out in the modified line plot system, which on the line comprises of con-
centric sample plots, of 200 m apart.

The outer circular sample plot of 17.85 m in radius (0.1 ha)
was used to tally the trees having the diameter at breast height bigger
than 10 cm and up. The middle circular plot of 12.62 m in radius (0.05 ha)
was used for enumeration of tree polings which having the diameter at
breast height less than 10 cm but taller than 1.30 m. The inner circular
plot of 5.64 m in radius (0.01 ha) was used for tallying tree saplings and
seedlings or natural forest regeneration. The square tract of 100 x 100 m
(1 ha) was used for tree enumeration in the farm forest.

2. Rangeland potential assessment.

An evaluation of rangeland potential site in Khon Kaen and
Mahasarakam provinces were firstly identified from the band 5 LANDSAT
imageries with the aid of photographic maps. Ground survey was carried
out to observe the grazing capacity, forage species composition and other
related factors.

3. Soil evaluation

The studies are designed to evaluate the soil fertility of
each province .

4. Micro watershed assessment

The determination of photo or map marked potential sites is
conducted by the field survey and analysis of water resource parameters.
The amount of direct runoff (R) for the designed storm which is assumed to
have return period of 25 years and duration of 2 years can be obtained from
automatic rain guages distributed throughout the Northeast.

## RESULTS AND DISCUSSION

Land-Use Classification of Khon Kaen and Mahasarakam Provinces

Interpretation of the LANDSAT imageries of Khon Kaen province, four main land-use categories can be classified; urban and built-up land, agricultural land, forest land, and water resources and can be described by modified land-use classification system of Wacharakitti, (1979) as Table 1.  Evidecnce from the Forest inventory are shown in Table 2.

### National Reserved Forest

The national forest policy with the agreement of the Royal Forest Department, Ministry of Agriculture and Cooperatives has been announced the forest area (Table 3 and 4) to be reserved for sustainable uses in the long run.

Table 1.   General land-use classification of Khon Kaen and Mahasarakam
           provinces from 1 : 250,000 scale black and white LANDSAT
           imageries taken in 1979

| Type of land use | Area of Khon Kaen | | Area of Mahasarakam | |
|---|---|---|---|---|
| | sq.km. | % of total | sq.km. | % of total |
| URBAN AND BUILT-UP LAND | 35.00 | 0.33 | 18.00 | 0.31 |
| AGRICULTURAL LAND | 7,698.33 | 72.42 | 4,481.28 | 77.48 |
| Paddy field | 1,001.00 | 9.42 | 969.00 | 16.75 |
| Field crop mixed with trees (Farm Forest) | 6,697.33 | 63.00 | 3,512.28 | 60.73 |
| FOREST LAND | 2,563.64 | 24.12 | 1,251.92 | 21.64 |
| Dry evergreen forest | 193.00 | 1.82 | | |
| Mixed deciduous forest | 406.95 | 3.83 | | |
| Dry dipterocarp forest | 293.57 | 2.76 | | |
| Swidden areas | 1,670.12 | 15.71 | 1,251.92 | 21.64 |
| WATER RESOURCES | 333.04 | 3.13 | 32.80 | 0.57 |
| Reservoirs | 233.90 | 2.20 | 17.00 | 0.30 |
| Natural lakes and ponds | 99.14 | 0.93 | 15.80 | 0.27 |
| Total | 10,630.01 | 100.00 | 5,784.00 | 100.00 |

Table 2. Density, merchantable volume, and dry weight biomass of different forest types in Khon Kaen and Mahasarakam provinces

| Forest type | Area (ha) | Vertical Structure | Crown Density No.of tree/ha | Merchantable Volume $m^3$/total area | $m^3$/ha | Dry weight Biomass Ton/total area | Ton/ha |
|---|---|---|---|---|---|---|---|
| **Dry evergreen forest** | | | | | | | |
| Saw timber | 19,300 | 4 | 230 | 1,303,136 | 67.52 | 1,331,711.58 | 69.00 |
| Fuel wood | | | | 386,386 | 20.02 | | |
| **Mixed deciduous forest** | | | | | | | |
| Saw timber | 40,695 | 3 | 186 | 1,390,548 | 34.17 | 2,005,398.32 | 49.28 |
| Fuel wood | | | | 3,634,877 | 89.32 | | |
| **Dry dipterocarp forest** | | | | | | | |
| Saw timber | 29,357 | 3 | 311 | 164,986 | 5.62 | 661,800.72 | 22.54 |
| Fuel wood | | | | 1,223,606 | 41.68 | | |
| **Farm forest** | | | | | | | |
| Saw timber | - | 1 | 20 | - | 17.55 | - | 14.47 |
| Fuel wood | | | | | 18.86 | | |

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Table 3    National Reserved Forest of Khon Kaen Province in 1981

| No. | Name | Location (Amphoe) | Area km$^2$ | rai |
|---|---|---|---|---|
| 1 | Dong Lan | Chumpae, Srichomphu | 340,500.00 | 544.80 |
| 2 | Phu Wieng | Chumpae, Phu Wieng | 218,162.50 | 349.06 |
| 3 | Kud Nam Sai | Phu Wieng | 6,093.75 | 9.75 |
| 4 | Hua Fai | Phu Wieng | 14,843.75 | 23.75 |
| 5 | Nong Ang | Phu Wieng | 11,718.75 | 18.75 |
| 6 | Nong Nok Kian | Nong Rua, Phu Wieng | 22,006.25 | 35.21 |
| 7 | Sok Tae | Muang, Ban Fang | 51,193.75 | 81.91 |
| 8 | Savathi | Muang, Ban Fang | 17,656.25 | 28.25 |
| 9 | Sam Ran | Muang | 29,275.00 | 46.84 |
| 10 | Khao Suan Kwang | Nam Pong | 38,750.00 | 62.00 |
| 11 | Huai Seaw | Nam Pong | 41,600.00 | 66.50 |
| 12 | Dong Moon | Kranual | 109,375.00 | 175.00 |
| 13 | Nong Mek, Lumpuk | Ban Pai | 128,250.00 | 205.20 |
| 14 | Non Nam Bang | Ban Pai, Phon | 152,343.75 | 243.75 |
| 15 | Kok Talad Yai | Ban Fang, Nong Rua | 37,775.00 | 60.44 |
| 16 | Kok Luang (1-2) | Manjakiri | 129,612.50 | 207.38 |
| 17 | Kok Luang (3) | Manjakiri | 92,187.50 | 147.50 |
| 18 | Phu Ragam | Manjakiri, Chonnabot | 158,050.00 | 252.88 |
| | Total | | 2,559.03 | 1,599,393.80 |

Table 4.    National Reserved Forest of Mahasarakam Province in 1981

| No. | Name | Location | Area Km$^2$ | Rai |
|---|---|---|---|---|
| 1 | Kok Khao | Chiangyuan | 11.85 | 7,406.25 |
| 2 | Din Daeng-Wang Kung | Kosoom | 122.00 | 76,250.00 |
| 3 | Kud Rang | Borabue | 240.00 | 150,000.00 |
| 4 | Kok Kham Pom | Muang | 17.00 | 10,625.00 |
| 5 | Dong Keng-Nong-Ya-Pong | Borabue | 17.50 | 10,937.50 |
| 6 | Kok Hin Lad | Muang | 6.00 | 3,750.00 |
| 7 | Kok Somrong-Po Phan | Na Chuak | 1.38 | 862.50 |
| 8 | Kok Pak Kud-Pong Daeng | Borabue-Na Chuak | 30.06 | 18,787.50 |
| 9 | Nong Ku-Na Doon | Wapipathum-Na Chuak | 47.00 | 29,375.00 |
| | Total | | 492.79 | 307,993.75 |

## Forest Depletion

Comparison of area measurements for each land-use between those two dates provides an initial estimate of the evolution of the land-use pattern in the two provinces as shown in Table 5 and 6.

## Encroachment of National Reserved Forest

The determination of the national reserved forest encroachment was performed by overlaying the existing land-use map of 1979 with the national reserved forest map which provides the data on illegal and legal encroachments of Khon Kaen and Mahasarakam provinces as illustrated in Table 7.

## Rangeland Potential in Khon Kaen and Mahasarakam Provinces

Most of the original forest cover was of no commercial value. The forest range plays an important role, particularly, during the wet season where the paddy fields and other agricultural lands are planted the crops and no room is available for cattle. But during the dry season after the rice and other cash crops have been harvested, a potential of 773,332 ha (72.75%) of cropland in Khon Kaen province and 449,928 ha (77.79%) in Mahasarakam province also can be used for grazing purpose. The animals are herded and grazed on agricultural land, grazing rice stubble, and any weed grasses that being sprout at the time. Paddy fields which are covered by various grasses are grazed heavily in this season.

Table 5    General land-use evolution in Khon Kaen province between 1973 and 1979

| Type of land-use | Area in sq km | | Area change | | |
|---|---|---|---|---|---|
| | 1973 | 1979 | sq km | %<br>(6 yrs) | %<br>(Yearly) |
| Natural forest land | 6,336.71 | 2,563.64 | -3,773.07 | -35.49 | -16.28 |
| Urban and built-up land | 29.00 | 35.00 | +6.00 | +0.06 | +3.09 |
| Agricultural land | 3,983.30 | 7,698.33 | +3,715.03 | +34.95 | +10.40 |
| Water resource | 281.00 | 333.04 | +52.04 | +0.49 | +2.79 |
| Total | 10,630.01 | 10,630.01 | – | – | – |

Table 6    General land-use evolution in Mahasarakam province between 1973 and 1979

| Type of land-use | Area in sq km | | Area change | | |
|---|---|---|---|---|---|
| | 1973 | 1979 | sq km | %<br>(6yrs) | %<br>(Yearly) |
| Natural forest land | 2,365.96 | 1,251.92 | -1,114.04 | -19.26 | -11.19 |
| Urban and built-up land | 15.00 | 18.00 | +3.00 | +0.05 | +2.99 |
| Agricultural land | 3,376.04 | 4,481.28 | +1,105.24 | +19.11 | +4.61 |
| Water resource | 27.00 | 32.80 | +5.80 | +0.10 | +3.19 |
| Total | 5,784.00 | 5,784.00 | – | – | – |

Notation :    + sign refers to the increasing in the area.

-- sign refers to the decreasing in the area.

Table 7.   Summary of illegal encroachment of national reserved forest
           of Khon Kaen and Mahasarakam Provinces in 1979

| Province | Land-use type | Area | |
|---|---|---|---|
| | | Sq.km. | % |
| Khon Kaen | Forest land | 2,563.64 | 24.12 |
| | National reserved forest | 2,559.03 | 24.07 |
| | Agricultural land | 7,698.33 | 72.42 |
| | Legal encroachment | 6,617.28 | 62.25 |
| | Illegal encroachment* | 1,081.05 | 10.17 |
| Mahasarakam | Forest land | 1,251.92 | 21.64 |
| | National reserved forest | 492.79 | 8.52 |
| | Agricultural land | 4,481.28 | 77.48 |
| | Legal encroachment | 4,263.89 | 73.72 |
| | Illegal encroachment* | 217.39 | 3.76 |

Notation  :   * Encroachment of the national reserved forest.

## Soil Studies of Khon Kaen and Mahasarakam Provinces

The comparison of soil quality among the two land-use types revealed that in terms of physical properties, most of the agricultural lands are less in the gravel content, being heavy in its voluminous mass, few root content or even meagerly observed. The particle density of the mineral soil is not significantly different since it derived from the similar soil textural classes (Table 8).

In regard to soil chemical properties, the agricultural lands of the two provinces are poor in organic matter, nitrogen, phosphorus, potassium and magnesium contents which substitute the major element of soil chemical properties as compared to the forest lands through soil reaction (pH) suggests the comparatively strong acidity (Table 9).

## Small Scale Reservoir Development Alternatives

With respect to the alternatives and their associated problems, ground investigation and assessment were conducted to every proposed sites.

Evidence from the studies shows that the potential and recommended small scale reservoir sites in Khon Kaen province are; K1 and K6 is suitable for shallow well, K2, K5, and K8 is suitable for village tank, and only K7 is suitable for deep well (Table 10). It is also recommended that in Mahasarakam province, the potential sites for village tank are M3 and M6, and for deep well are M1, M5 and M7 (Table 10).

Table 8   Physical properties of soils in the two land-use patterns

of Khon Kaen and Mahasarakam Provinces[1]

| Properties | Land-use type | Soil depth (cm) | | | |
|---|---|---|---|---|---|
| | | 0-5 | 10-20 | 20-30 | 50-70 |
| Gravel | Agricultural land | 0.06 | 0.09 | 0.06 | UD[2] |
| (%) | Forest land | 4.59 | 2.39 | 14.74 | 17.95 |
| Root | Agricultural land | - | - | - | - |
| (%) | Forest land | 0.08 | 0.07 | 0.07 | 0.007 |
| Bulk density | Agricultural land | 1.69 | 1.48 | 1.60 | 1.69 |
| (gm/cc) | Forest land | 1.40 | 1.50 | 1.48 | 1.61 |
| Particle densi-ty | Agricultural land | 2.64 | 2.51 | 2.52 | 2.53 |
| (gm/cc) | Forest land | 2.57 | 2.62 | 2.65 | 2.52 |
| Porosity | Agricultural land | 35.67 | 41.00 | 36.67 | 32.00 |
| (%) | Forest land | 45.67 | 42.33 | 43.67 | 35.00 |

Notation :  1/  Mean of 3 samples for the agricultural land and

5 samples for the forest land

2/  UD = Undetected

Table 9    Chemical properties of soils in the two land-use patterns of Khon Kaen and Mahasarakam Provinces[1]

| Properties | Land-use type | Soil depth (cm) | | | |
|---|---|---|---|---|---|
| | | 0-5 | 10-20 | 20-30 | 50-70 |
| pH | Agricultural land | 4.67 | 4.83 | 4.97 | 5.17 |
| | Forest land | 4.94 | 4.72 | 4.68 | 4.60 |
| Organic matter (%) | Agricultural land | 0.53 | 0.29 | 0.23 | 0.26 |
| | Forest land | 1.34 | 0.56 | 0.47 | 0.14 |
| Nitrogen (%) | Agricultural land | 0.028 | 0.015 | 0.012 | 0.013 |
| | Forest land | 0.067 | 0.028 | 0.023 | 0.007 |
| Phosphorus (ppm) | Agricultural land | 2.67 | 2.33 | 2.67 | 2.33 |
| | Forest land | 3.00 | 2.00 | 1.20 | 1.30 |
| Potassium (ppm) | Agricultural land | 25.00 | 17.00 | 16.67 | 22.67 |
| | Forest land | 57.60 | 31.40 | 31.60 | 30.67 |
| Calcium (ppm) | Agricultural land | 165.33 | 181.33 | 92.67 | 207.30 |
| | Forest land | 273.60 | 86.80 | 127.60 | 6.00 |
| Magnesium (ppm) | Agricultural land | 31.00 | 30.00 | 19.00 | 35.00 |
| | Forest land | 113.80 | 71.80 | 58.80 | 23.70 |
| Sodium (ppm) | Agricultural land | 96.67 | 101.00 | 120.67 | 506.00 |
| | Forest land | 70.20 | 71.00 | 72.60 | 128.00 |

Notation : [1] Mean of 3 samples for the agricultural land and 5 samples for the forest land

Table 10    Recommended and Potential Sites of Small Scale Reservoir

| Sites | Degree of Seriousness of Water Shortage (1 to 10) | Potential of Scheme Development (1 to 10) | | | Recommended Scheme |
|-------|------|------|------|------|------|
| | | Village Tank | Shallow Well | Deep Well | |
| K1 | 4 | 8 | 8 | 7 | SW[1] |
| K2 | 7 | 8 | 5 | 5 | T[2] (Huay Yai) |
| K3 | 10 | 3(sa) | 4(y) | 4(sa) | ?[3] |
| K4 | 1 | 8 | 4(y) | 8 | -[4] |
| K5 | 4 | 6 | 4(y) | 5 | T (Nong Tan) |
| K6 | 5 | 4(sa,se) | 7 | 3(sa) | SW |
| K7 | 9 | 4(se) | 3(y) | 8 | DW[5] |
| K8 | 4 | 8 | 7 | 7 | T (Huay Ak) |
| M1 | 8 | 3(se) | 6 | 8 | DW |
| M2 | 3 | 5(sa) | 7 | 7 | - |
| M3 | 8 | 8 | 4(y) | 7 | T (Huay Noi) |
| M4 | 10 | 4(sa) | 2(m) | 2(sa) | ? |
| M5 | 8 | 3(se) | 3(y) | 8 | DW |
| M6 | 7 | 6 | 4(y) | 2(m) | T (Huay Sok Pue) |
| M7 | 7 | 7 | 4(y) | 8 | DW |

| | | | |
|---|---|---|---|
| 1/ | SW | = | Shallow well |
| 2/ | T(...) | = | Village tank it means that the stream that should be dammed |
| 3/ | ? | = | no scheme is recommended due to inferior location |
| 4/ | - | = | no scheme is recommended due to existing |
| 5/ | DW | = | deep well |
| | K | = | Khon Kaen |
| | M | = | Mahasarakam |

## CONCLUSIONS

Four main land-use categories; urban and built-up land, agricultural land, forest land and water resources can be classified in both of Khon Kaen and Mahasarakam province on the imagery scale of 1 : 250,000. Forest depletion in both Khon Kaen and Mahasarakam province was determined. Evidence from the studies shows that during the past 6 years (from 1973 to 1979), the forested land of Khon Kaen province was decreased from 633,670 ha to 256,300 ha (16.28% per annum), and at Mahasarakam province the forest depletion was also occurred from 236,596 ha in 1973 to 125,193 ha in 1979 (11.19% per annum).

It was found that several disturbed forested areas that suitable for rangeland development in both Khon Kaen and Mahasarakam provinces. For example, rangeland potential for development were at Amphoe Phuwieng, Nampong, Kranual, Manjakiri and Phon of Khon Kaen, while in Mahasarakam province were at Borabue, and Phayakkaphumpisai.

The comparison of soil quality among the two land-use types revealed that in terms of physical properties, most of the agricultural lands are less gravel content, being heavy in its voluminous mass, few root content or even meagerly observed. The porosity of soil in the agricultural lands is less than those in the forest lands.

Evidence from the small scale reservoir studies shows that the potential and recommended small scale reservoir sites in Khon Kaen province are; K1 and K6 for shallow well, K2, K5 and K8 for village tank, and K7 for deep well, while at Mahasarakam province the potential sites for small scale reservoir are; M3 and M6 for village tank, M1, M5 and M7 for deep well.

RECOMMENDATIONS

## 1. Reforestation project

Forested areas of Khon Kaen and Mahasarakam provinces were extensively destructed, which caused negative impacts to the general environment of the two provinces. The disturbed forested areas are very much in need of reforestation to put them back to productive and useful conditions.

## 2. Community forest project

Energy sources in term of fuel wood of the two provinces are reducing and far away in the future. Therefore, community forest project for fuel wood utilization in the future should be set up to reforest the hilly areas by introducing fast growing tree species.

## 3. Rangeland improvement and livestock raising promotion project

Government support for rangeland development and livestock raising promotion to the farmers are urgently needed in the two provinces.

## 4. Small scale reservoir development project

Water resources to supply water for agriculture and domestic consumption for the rural poor people and livestocks are needed.

## 5. Agricultural extension project

The rural poor people in the village areas are still far from agricultural technical know how, therefore agricultural extension; in term of intensive training in plant selection, cultivation technique, fertilizer, pesticide and water management are also needed.

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