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Original Article

Change detection and identification of land potential for planting Krajood *(Lepironia articulata)* in Thale Noi, Southern Thailand

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Abstract

Lepironia articulata, commonly called grey sedge or krajood, can be transformed into various products to generate extra income for local families in the southern part of Thailand. In recent years, the amount of *Lepironia articulata* used as raw material has decreased and does not currently meet the demand for the resource. Appropriate areas where natural resources and the environment can be restored and the abundance of natural produce can be increased must be sought. Therefore, this research considered the opportunity to identify appropriate areas for planting *Lepironia articulata*. Geographic information system (GIS) and remote sensing were integrated to map land use changes in 1990, 1998 and 2006 in the Thale Noi area. The study found that from 1990-1998, emergent aquatic areas increased by 16.18 square kilometers, the area of swamp forests increased by 15.33 square kilometers, the area of rice paddies decreased by 0.80 square kilometers, and the area of mixed orchards increased by approximately 0.32 square kilometers. From 1998-2006, the area of swamp forests increased by 1.9 square kilometers, but emergent aquatic areas decreased by 1.23 square kilometers. The area of rubber plantations increased by 0.63 square kilometers, and the area of rice paddies decreased by 0.69 square kilometers. This study aimed to define land potential for Krajood (*Lepironia articulata*) cultivation in the Thale Noi area by considering five factors: land use, distance from water sources, slope, soil characteristics, and soil drainage. The study found that the areas of high potential for planting *Lepironia articulata* were wetlands and near water sources, covering a total area of 5.54 square kilometers. The areas with moderate potential were swamp forests and rice paddies, covering a total area of 4.27 square kilometres. GIS and remote sensing were found to be very useful for identifying land use changes and potential areas for planting *Lepironia articulata*.

Keywords: land potential, *Lepironia articulata,* Thale Noi, GIS

1. Introduction

The Thale Noi wetland is a habitat for various types of bird. Moreover, it has been occupied by a variety of water plants. Surrounding areas include freshwater swamps, where *Lepironia articulata* and *Pandanus amaryllifolius* Roxb shrubs grow. Currently, the Thale Noi wetland is established as a national marine park. It comprises a significant number of plains and canals that flow into Songkhla Lake. These exclusive geographic features have created a wetland of high biological diversity. However, continuous usage and invasion have led to the degradation of wetland resources (ONEP, 1997), which has inevitably affected residents of the surrounding area.There have been some problems in the Thale Noi wetland. First, local people have overused natural

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materials, such as *Lepironia articulata*, that are available in the area to earn extra income. *Lepironia articulata* can be transformed into various products (e.g., mats) to generate extra income for local families in the southern part of Thailand. Over recent years, the volume of *Lepironia articulata* available for use as raw material has decreased and has been insufficient for demand. In particular, there is not currently a large volume of *Lepironia articulata* in the sanctuary (non-hunting) area of Thale Noi for the local demand, who have thus had to purchase *Lepironia articulata* from other areas, such as Nakhon Si Thammarat. The reason for the shortage of raw materials in the Thale Noi area is that the local people have harvested the plant without considering the sustainability of their actions. To support the economy, society and local culture, there is a need to find a method of restoring the local *Lepironia articulata* supply.

As there has been no in-depth research regarding the planting of *Lepironia articulata* in Thailand, this study considered using satellite imagery, GIS and remote sensing to identify appropriate areas for growing *Lepironia articulata* to provide sufficient amounts of *Lepironia articulata* to meet the demands of the people utilising *Lepironia articulata* for the sustainable production of a variety of products.

2. Methodology

2.1 Scope of the study area

The Thale Noi wetland area is located to the north of Songkhla lake (Figure 1) at a latitude of 7° 45′ to 7° 50′N and longitude of 100° 09′ to 100° 15′E.

2.2 Analysis of land use changes

Land use changes were analysed by overlaying the land use data stored in the database during different periods and assessed via spatial analysis using GIS. The measures utilised for the spatial analysis are indicated in Figure 2.

2.3 Analysis to identify potential areas for planting *Lepironia Articulata*

GIS was applied to identify potential areas for planting *Lepironia articulata*. The processes of the study are described below.

2.3.1 Literature review to identify land characteristics suitable for planting *Lepironia articulata*, including physical and biological elements, the ecological characteristics of *Lepironia articulata* (Young, R.D., Dahl, T.E., 1994; Spruce, J. *et al*, 1996; Schulz, J. M., 2000; Sutter, L., 2000; Ratanasermpong, S. *et al*, 2000), and factors related to the impacts of humans on *Lepironia articulata's* ecosystem.

The five crucial factors associated with the selection of areas for planting *Lepironia articulata* were 1) current land use, 2) distance from water sources, 3) slope, 4) soil characteristics, and 5) soil drainage.

2.3.2 Evaluating factors to identify the suitability of areas for planting *Lepironia articulata*.

These five factors were related to the feasibility and physical characteristics of *Lepironia articulata* and social factors related to the land use management of the area. These factors were measured by setting a score for each main factor and sub-factor and were based on a scoring system of 1 to 5 points, with a higher score representing a condition that was suitable for planting *Lepironia articulata*. In this study, the weighted values of the main factors and sub-factors were divided into five levels.

Figure 1. Map of the study area.

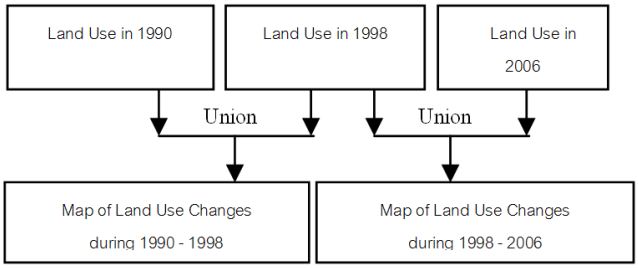

Figure 2. Process for analysing wetland changes.

2.3.3 In the weighting method process, this selection was used to obtain a weighted scoring that was consistent with the data obtained by 46 experts. To obtain feedback from experts regarding these factors' importance, a questionnaire was conducted to acquire the outcomes that would later be utilised in the weighted scoring of each factor using a simple weighting analysis. Then, the total score of each factor in the study was calculated to identify suitable areas for planting *Lepironia articulata* using the following linear regression equation:

$$S = W_1R_1 + W_2R_2 + W_3R_3 + ... + W_nR_n$$

where S = the ability or the level appropriate for the study.
W = the weighted score of the main factors.
R = the weighted score of the sub-factors.

2.3.4 After data gathering and preprocessing, each variable from these five factors was evaluated for weighted scoring and scored based on the relative potential of the area (where 5 represented the value of areas with the highest potential, 4 was areas with more potential, 3 was areas with moderate potential, 2 was areas with less potential, and 1 was areas with the least potential). Each variable then generated a weighted score according to its significance and relationship to potential areas for planting *Lepironia articulata*. Finally, all of the layers were overlaid, and the score of each variable was incorporated into the potential area. After the variables were ranked and the areas' levels of potential were classified, the values were added to determine whether the potential area was a very low, moderate, or high potential area for planting *Lepironia articulata.*

3. Results

3.1 Analysis of land use changes in the Thale Noi area

In this study, the results of the analysis of land use changes were derived from land uses in 1990, 1998 and 2006. The results of this analysis in the study area were divided into two parts: the changes from 1990 to 1998 and those from 1998 to 2006. The obtained changes in the study area are represented in the form of a comparison graph (Figure 3).

3.1.1 Analysis of land use changes in the Thale Noi area from 1990 to 1998

This analysis compared data on the changes in the area of each land use type. In addition to natural changes, the changes were also caused by manmade changes, especially in agricultural areas. The results showed that the areas of rubber plantations and rice paddies decreased by 0.37 km^2 and 0.80 km^2, respectively, while 0.32 km^2 of mixed orchards developed in an area that had previously been rubber fields and rice paddies.

3.1.2 Analysis of land use changes in the Thale Noi area from 1998 to 2006

This analysis compared data illustrating the changes in the area of each land use type. In addition to natural changes, the changes were also caused by manmade changes,

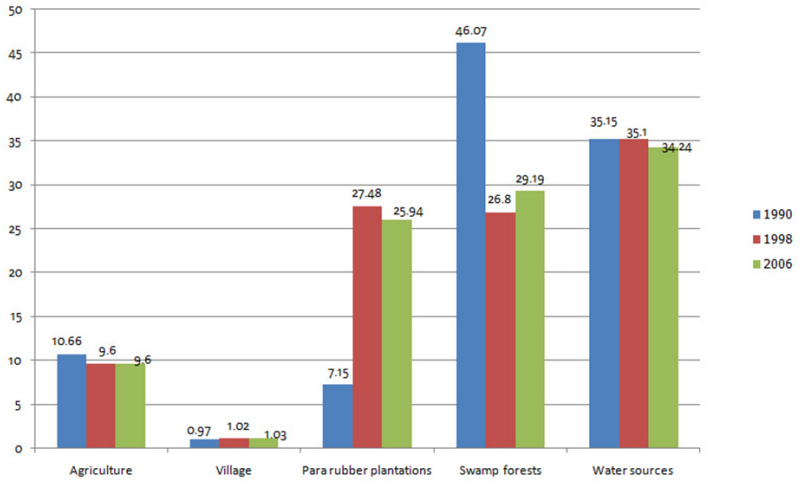

Figure 3. Land use changes in the Thale Noi area from 1990 to 2006

especially in agricultural areas. The results showed that the area of rubber plantation increased by 0.63 km^2, while the area of rice paddies decreased by 0.69 km^2. Due to the higher price of rubber, farmers increasingly turned their rice paddies into rubber fields.

3.2 Factors affecting the potential cultivation areas for *Lepironia articulata* in the Thale Noi area

1) Land use

Land use was an important factor for defining the potential areas for planting *Lepironia articulata*. In this study, seven types of land use were used in the classification: 1) marsh, 2) villages, 3) rice paddies, 4) swamp forests, 5) rubber fields, 6) natural water bodies, and 7) mixed orchards.

2) Distance from water sources

Distance from water sources was an important factor for cultivating *Lepironia articulata*. Therefore, this study classified the distance from water sources into four levels: 1) 0-1 kilometers away from water sources, 2) 1-2 kilometers away from water sources, 3) 2-3 kilometers away from water sources, and 4) more than 3 kilometers away from water sources.

3) Slope

The slope was hierarchically classified into two levels: 1) 0-2% slope, and 2) 2-5% slope.

4) Soil characteristics

The soils in the study area were classified into four types: 1) loamy soil, 2) mudflat soil, 3) clay, and 4) silty soil

5) Soil drainage

Soil drainage in the study area was classified into four levels: 1) well drained, 2) somewhat excessively drained, 3) somewhat poorly drained, and 4) very poorly drained.

3.3 Analysis of defining the restoration potential of areas for cultivating *Lepironia Articulata* in the Thale Noi Area

3.3.1 Scoring of the main factors and sub-factors

Based on the questionnaire regarding the weighted score of the main factors that was sent to people experienced in growing *Lepironia articulata*, the authors of this study determined the factors that are suitable for growing *Lepironia articulata*, as shown in the Table 1.

3.3.2 Analysis of wetland restoration potential for *Lepironia articulata*

The data to be analyzed for the "Land potential for the Cultivation of *Lepironia articulata*" study were collected from experts in the field, as shown in Table 1. Based on these factors, a spatial analysis was conducted to identify potential areas for cultivating *Lepironia articulata* based on a rating system. The weighted linear total is provided in terms of the following equation:

$$S = (W_1R_1) + (W_2R_2) + (W_3R_3) + ... + (W_nR_n)$$

where S = the ability or level appropriate for the study.
W = the weighted score of the main factors.
R = the weighted score of the sub-factors.

This equation was used to calculate the potential score to assess land potential for cultivating *Lepironia articulata*, as shown in Table 1.

The study classified the potential for cultivating *Lepironia articulata* into three levels.

- Areas with low potential for cultivating *Lepironia articulata* had a value of less than $\overline{X} - SD$.
- Areas with moderate potential area for cultivation of *Lepironia articulata* had a value between $\overline{X} - SD \leq S \leq \overline{X} + SD$.
- Areas with high potential area for cultivation of *Lepironia articulata* had a value greater than $\overline{X} + SD$.

3.3.3 Potential areas for cultivating *Lepironia articulata* in the Thale Noi area

This study found that approximately 0.68 km^2 (6.5%) of the study area had values of less than 10.757, denoting low potential for cultivating *Lepironia articulata*. Approximately 4.27 km^2 (40.7%) had values between 10.757 and 15.449, denoting moderate potential for cultivating *Lepironia articulata*. Finally, 5.54 km^2 (52.8%) of the study area had high potential for growing *Lepironia articulata*, with values greater than 15.449, as shown in Table 2 and Figure 4.

1) Land with low potential for cultivating *Lepironia articulata* covered 0.68 km^2(6.5%) of the study area. These areas were rubber plantations or rice paddies and were located far from water sources.

2) Land with moderate potential for cultivating *Lepironia articulata* covered 4.27 km^2 (40.7%) of the study area. These areas were swamp forests or rice paddies and were located near water sources.

3) Land with high potential for cultivating *Lepironia articulata* covered 5.54 km^2 (52.8%) of the study area. These areas included wetlands, areas near water sources, and areas around the shore of Thale Noi.

The study identified the types of land use that were in the potential areas for cultivating *Lepironia articulata* in

Table 1. the Potential of each factor to this study.

Main Factor in the Study	Sub-factor	Weighted score of main factors(W)	Weighted score of sub-factors(R)	WR
1. Land Use	1.1) Marsh	4.457	4.304	19.183
	1.2) Rice Paddies		3.391	15.114
	1.3) Abandoned Rice Paddies / Fallow Areas		2.913	12.983
	1.4) Rubber Plantations		2.109	9.400
	1.5) Mixed Orchards		2.326	10.3670
	1.6) Swamp Forests		2.848	12.6935
2. Distance from Water Sources	2.1) away from water sources 0 – 1 km.	4.435	3.739	16.582
	2.2) away from water sources 1 – 2 km.		3.804	16.871
	2.3) away from water sources 2 – 3 km.		2.957	13.114
	2.4) away from water sources more than 3 km.		2.521	11.181
3. Slope	3.1) 0-2%	4.087	3.978	16.258
	3.2) 2-5%		3.457	14.129
	3.3) >5%		2.109	8.619
4. Soil Characteristics	4.1) Loamy Soil	4.370	4.304	18.808
	4.2) Mudflat Soil		4.609	20.141
	4.3) Clay		2.587	11.305
	4.4) Silty Soil		2.326	10.165
5. Soil Drainage	5.1) well drainage	4.043	1.500	6.065
	5.2) good drainage		1.761	7.120
	5.3) relatively good drainage		2.848	11.514
	5.4) poorly drainage.		3.478	14.062
	5.5) very poor drainage		4.348	17.579
	5.6) the worst drainage		4.369	17.664

Source: by data analysis

the study area by utilising land use data from 2006. This analysis found that the high-potential areas were mainly wetlands, with an approximate area of 3,459.85 Rai. The areas with moderate potential were mostly swamp forests, with an approximate area of 2,072.06 Rai, as shown in Table 3 and Figure 5.

4. Conclusions and Recommendations

From 1990 to 2006, the area of swamp forest increased due to a decrease in the amount of emergent aquatic and natural water sources because *Melaleuca leucadendron* was a dominant type of tree in swamp forests. In addition to natural changes, there were some manmade land use changes, especially in agricultural areas. The price of rubber was higher than that of rice; therefore, farmers increasingly converted rice paddies to rubber plantation areas.

In this study, to define potential areas for cultivating *Lepironia articulata* in the Thale Noi area, five factors were employed: land use, distance from water sources, soil characteristics, slope, and soil drainage. The study found that emergent aquatic and rice paddies. The emergent wetlands and rice paddies in 2006 were altered from swamp forests, covering a total area of 5.54 square kilometres. In the areas with moderate potential, 4.27 square kilometres were rice paddies. The current land use was an important factor for identifying potential areas for planting *Lepironia articulata* because the potential areas should have flexible land uses, be accessible, and be available for planting *Lepironia articulata*. Therefore, the urban areas, those in the district, and those with a high density of buildings were inappro-

Table 2. Results of the study to identify potential area for cultivation of *Lepironia Articulata* in Thale Noi area.

Level	Area (km^2)	percent
Low	0.68	6.5
Moderate	4.27	40.7
High	5.54	52.8
Total	10.49	100.00

Remark: The area from GIS analysis.

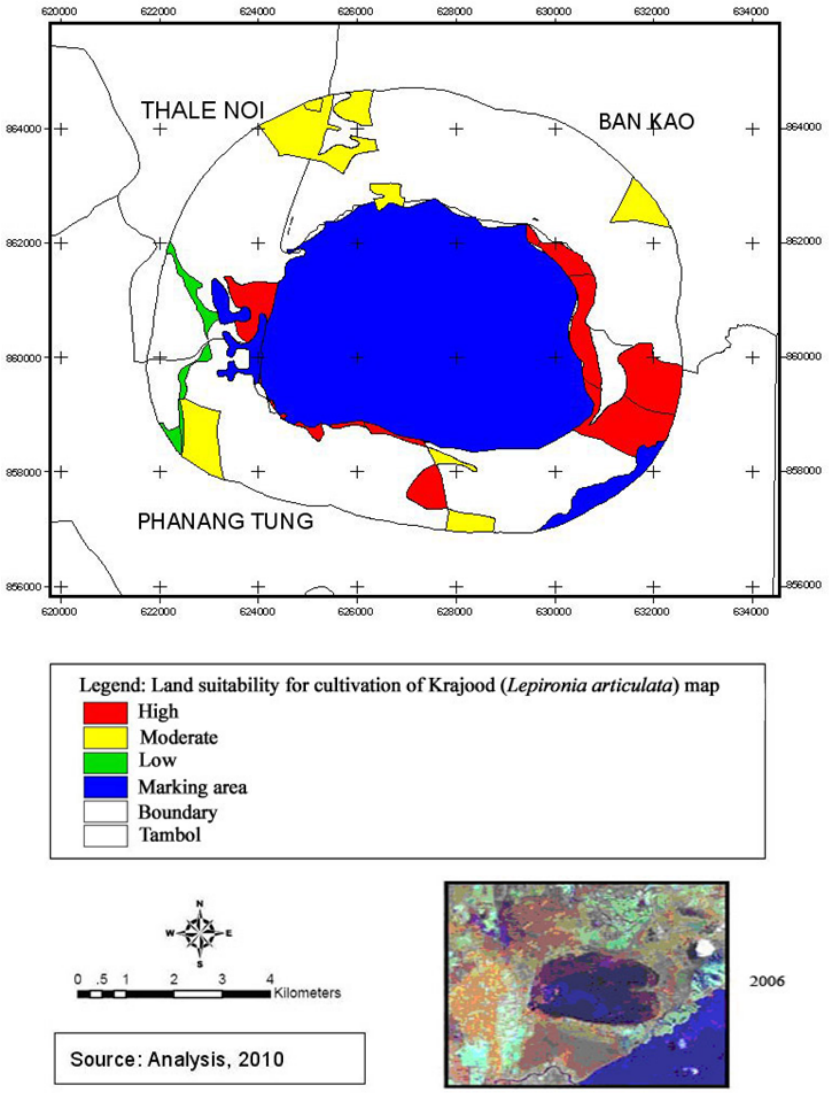

Figure 4. Map showing potential areas where *Lepironia articulata* could be cultivated in the Thale Noi area

priate for cultivation purposes. Furthermore, the areas in the upper reaches of rivers and forests were inappropriate because they are valuable from ecological and economical perspectives. Thus, the agricultural areas, abandoned areas, and rice paddies were feasible areas for cultivating *Lepironia articulata*. However, other land uses were also considered when determining where to cultivate *Lepironia articulata*. Areas near water sources were suitable for growing *Lepironia articulata* because the plant preferred to be in permanently flooded areas. Additional research should be conducted to identify the different depths of the water level, flooding frequencies, the types of substrates that can be used to grow peat and the soil and water pH levels that will increase the productivity of *Lepironia articulata*. The participation of all of the communities that can contribute to the sustainable preservation and utilisation of *Lepironia articulata* should be promoted. The costs and benefits of changing land use must be assessed to ensure that these changes lead to a net increase in benefits for the cultivation of *Lepironia articulata*.

5. Acknowledgements

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Table 3. Category of land use (in 2006) in the potential areas for cultivation of *Lepironia Articulata*.

Potential areas for cultivation of *Lepironia articulata*	Land use types	Area	
		Rai	Sq. km.
Low potential areas	Para rubber Plantations	350.50	0.56
	Mixed Orchards	66.50	0.12
	Total	417.00	0.68
Moderate potential areas	Swamp forest	2,072.06	3.32
	Rice paddies	598.33	0.96
	Total	2,670.38	4.27
High potential areas	Marsh	3,459.85	5.54
	Total		5.54
Grand Total	6,547.23	10.49	

Remark: Marsh: area used to be peat swamp forests in 1990

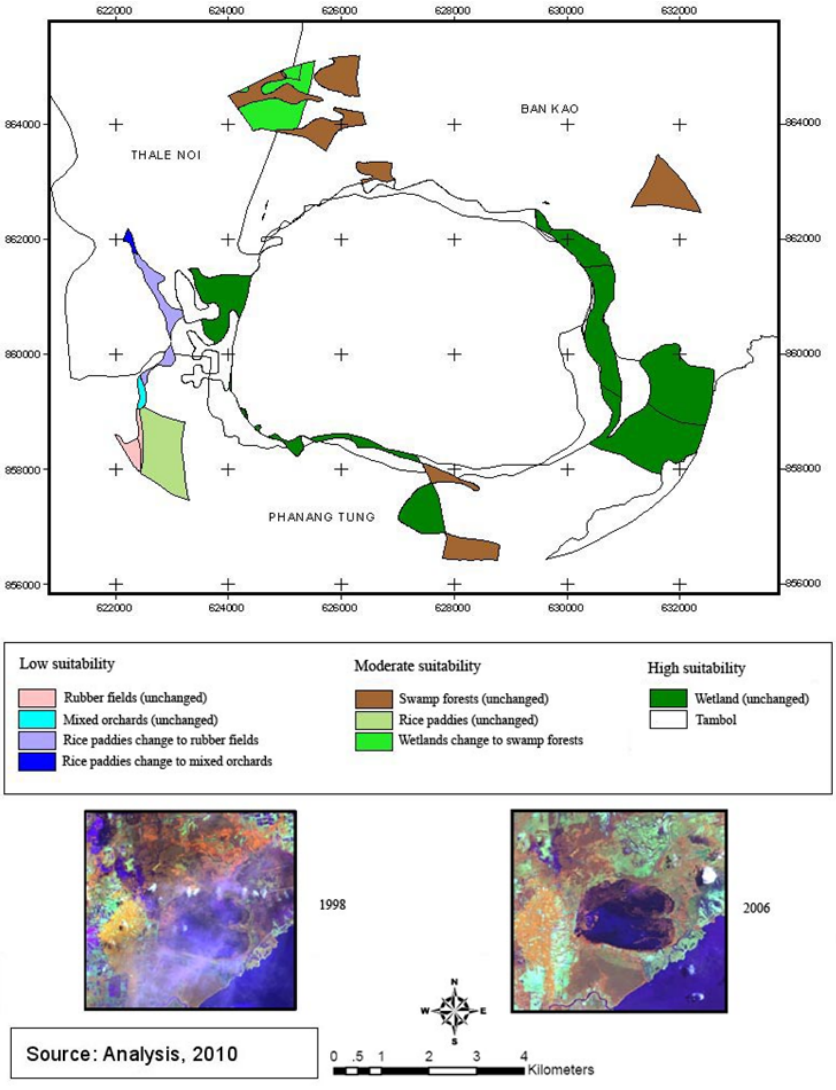

Figure 5. Land use (in 2006) in the potential areas for cultivating *Lepironia articulata*

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