Tropical agricultural ecology
(熱帯農業生態学特論)

1. Climates in the tropics (熱帯の気候)

2. Land use and farming systems
(土地利用と営農動態)

3. Agricultural resources and their changes in recent years (農業資源とその変化)

4. Present and future sustainable agricultural production in the tropics
(熱帯地域における持続的農業生産の今後)

Dynamics of land use and farming systems
(土地利用と営農動態)

１． Significance of agro- or agricultural ecology
(農業生態の意味)

２． Dynamics of land use in the tropics
(熱帯における土地利用動態)

３． Dynamics of farming systems
(熱帯における営農動態)

４． Methodologies of analysis (解析手法)

Significance of agro- or agricultural ecology

Narrow meaning of "農業生態"

Agroecology (耕地生態)

Agricultural field ecology (農地生態)

→ Ecosystem of agricultural spaces

Target : Crops, Domesticated plants

Diversified fauna and flora

(多様な動植物相)

Broad meaning of "農業生態"

Agricultural ecology

→ Ecosystem of a region including human and agricultural spaces

Target : Constituents of the agro-ecosystem

Human beings

(Culture, society, economics)

Dynamics of land use and farming systems
(土地利用と営農動態)

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４． Methodologies of analysis (解析手法)

Land use (土地利用)

↑

Topography (地形)・Climates (気候)・Soils (土壌)・
Ethnicity (民族)・ Population (人口)・Economy (経済)

Changes in land use (熱帯地域における土地利用の変化)

Causes (変動因)

1. Climatic changes (気候変動)
2. Soil deterioration (土壌劣悪化)
3. Population increase (人口増)
4. Economic development, globalization
   (経済発展・グローバリゼーションの進行)

Land use (土地利用)

↑

Topography (地形)・Climates (気候)・Soils (土壌)・
Ethnicity (民族)・ Population (人口)・Economy (経済)

Changes in land use (熱帯地域における土地利用の変化)

Population increase

Development of medicine in the tropics

Recovery of public order（地域秩序の回復 ）

→ Extension of public medical services to local areas

→ Improvement of agricultural production

→ Expansion of agricultural fields, agricultural development in natural vegetation

→ Deforestation, increase in vac

Dynamics of land use in Mainland Southeast Asia

Land use (土地利用)

↑

Topography (地形)・Climates (気候)・Soils (土壌)・
Ethnicity (民族)・ Population (人口)・Economy (経済)

Geographical classification of mainland Southeast Asia (東南アジア大陸部の地理区分)

1. Delta
2. Undulating plains (平原)
3. Mountainous areas (山地)

a) Delta

Irrawaddy Delta, Chaophraya Delta , Mekong Delta, Red River Delta

Estuary (河口部) of large river systems

Rainy & dry seasons

Flooding, hot & humid

Delayed development

Development of irrigation networks

Irrigated paddy production

Capital cities

a) Delta

Chaophraya Delta

Poor residential environment → Delayed development
(Seasonal flooding, long dry season, poorly developed natural levees [自然堤防] suitable for residence)
Construction of Rang Sit Canal network
→ Improvement of residential environment

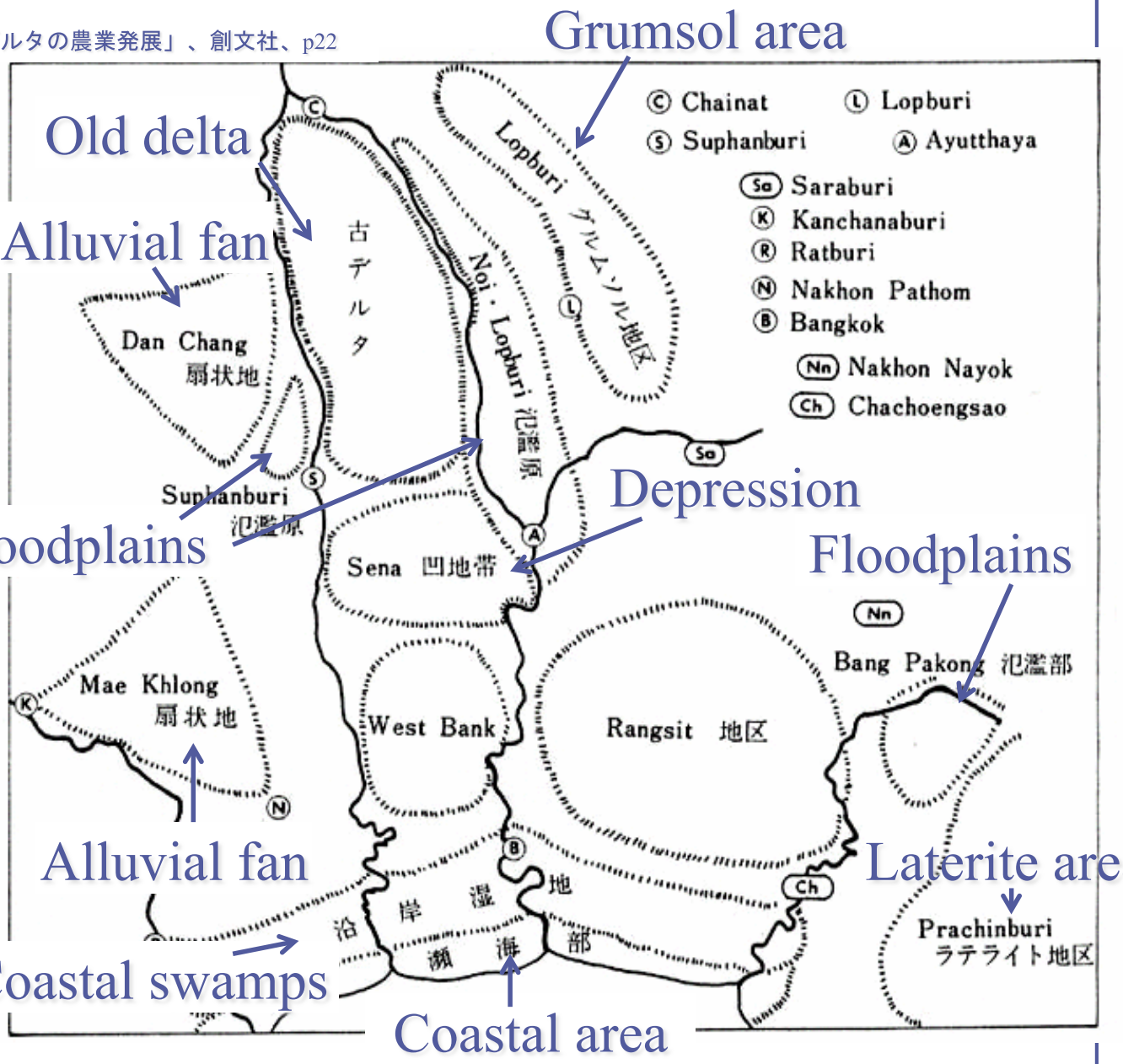
Traditional Rainfed paddy, floating & deep water rice
(伝統的天水稲作、浮稲と深水稲)
→ Development of irrigation networks →
Irrigated paddy production
→ World rice bowl (*世界の穀倉地帯*)

Metropolises → Development of horticulture

Delta structure

Chaophraya Delta

「熱帯デルタの農業発展」、創文社、p22



The Red River Delta (紅河デルタ)

Estuary of a large river system, low and flat, large area

Dry & rainy seasons, Flooding

Mountains directly to the Delta

Early development

Traditional rice production with small scale irrigation systems (Single cropping , 一期作)

→ Development of large scale irrigation systems

→ Double cropping (二期作)

→ Intensification (集約化) ,
Double cropping of rice + winter crops

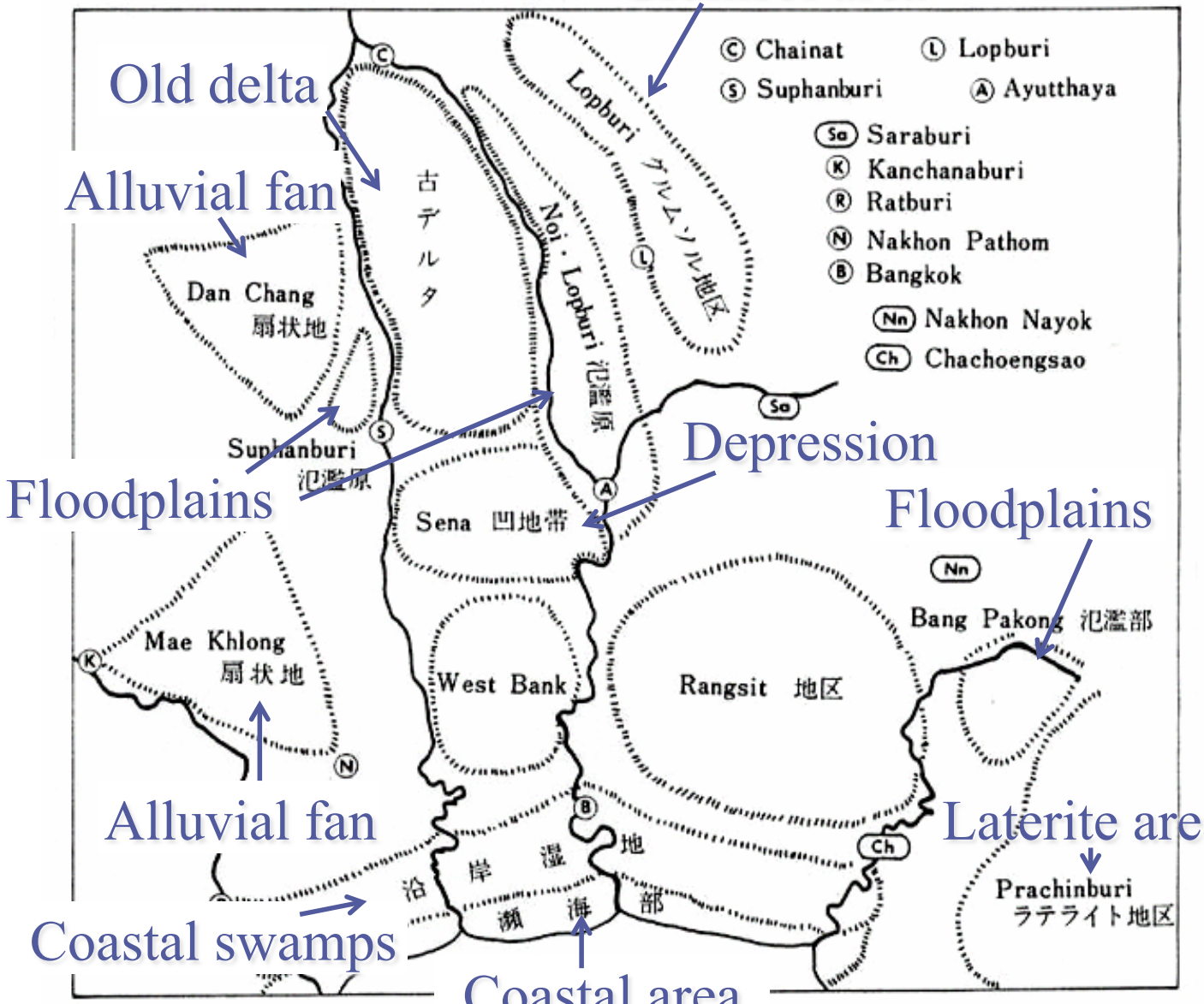
→ High production, Densely populated

(Too many people too small land)

Delta structure

Chaophraya Delta

「熱帯デルタの農業発展」、創文社、p22



Horticultural areas in coastal swamps

Tidal and brackish water areas
The Damneon Saduak Canal and other canals
Small horticultural fields surrounded by levees
High ridges and mixed cropping
Fruit trees, fruit vegetables & ornamental plants
Jom nam (indigenous technology)

Jom nam

Submerge a whole field for few days - 1 month

Sterilization

Desalination

Improvement of soil moisture

Jom nam

Vegetable production on the west bank

Central areas in new delta
Retarding basin at the end of rainy season
Priority for water use in dry season

Large flat ridges
Sole cropping
Leafy vegetables

b) Plains

Central Myanmar, Central and Northeast Thailand, Middle-south Laos, Cambodia

Undulating plains
Rainy & dry seasons
tropical savanna
Scarce water resources
Unstable rainfall
Original vegetation : Sparse forests
Rainfed agriculture, Instability
Large-scale upland development

b) Plains

Central Myanmar, Central and Northeast Thailand, Middle-south Laos, Cambodia

Traditional land use

Middle and high places in hilly undulating plains :

Natural vegetation, Sparse forest, Dipterocarp f.

Low places, flood plain :

Paddy rice production using small scale irrigation systems (tamnop) → Population growth

→ Rainfed paddy production

→ Upland field development

Local topography and paddy rice production

Good water conditions:
Early transplanting possible
High yields expected
Flood damage

Late varieties

Paddy fields

Local topography and paddy rice production

Paddy fields

Poor water conditions:

Late transplanting or transplanting impossible

Poor or no yields

No flood damage

Early varieties

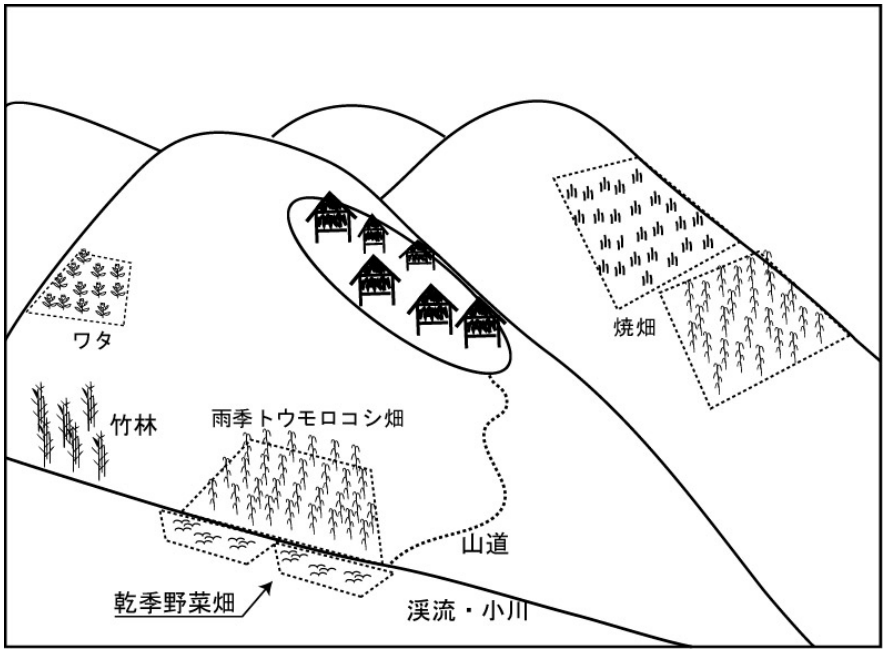
c) Mountains

North Myanmar, North Thailand,
North & Northwest Laos,
Northwest & Northeast Vietnam

Mountainous slopes・Valleys・Basins
→ Watershed

Rainy & dry seasons
Rich water resources
Cool climates
Shifting cultivation, Paddy rice using small scale irrigation, Horticulture
Ethnic minority, poppy or opium

a) Mountainous slopes



Shifting cultivation in slope lands

Cool climate →
Opium, highland vegetables

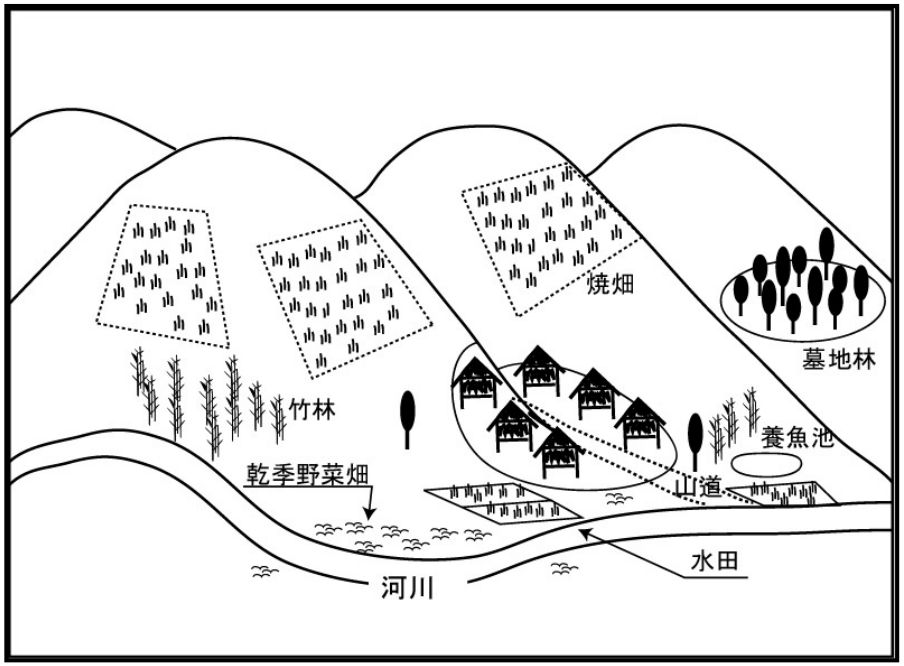
Most of mountainous area

Production → Rely on resources

Changes in shifting cultivation

Poor development of infrastructure

b) Valleys



Shifting cultivation in slope lands

Paddy fields in valleys

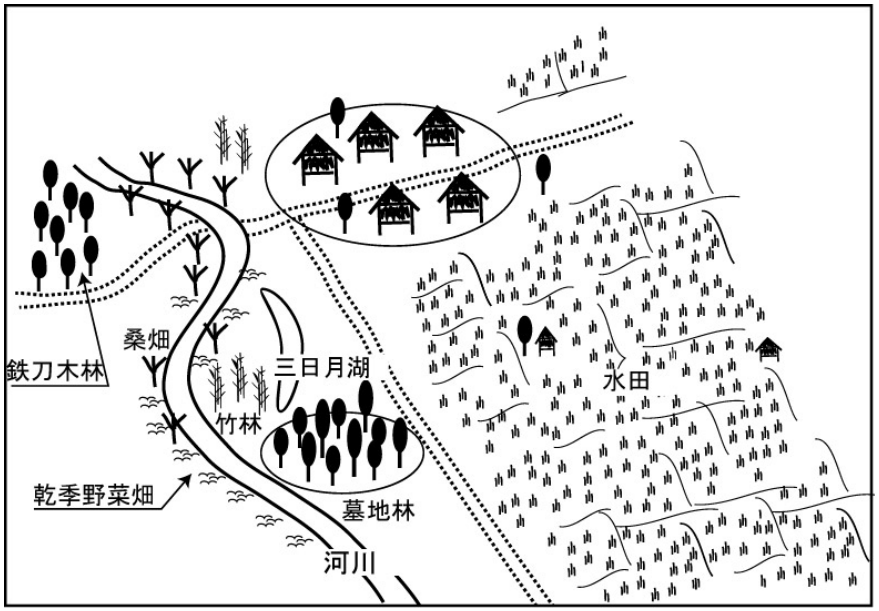
Good access

Resource depletion

Reduction in productivity

Poor development of infrastructure

c) Basins



Irrigated paddy fields, vegetable gardens

High productivity

Good access

Small area

Poor development of circulation machinery

Poor development of infrastructure

（Kanazawa. et al., 2006 より）

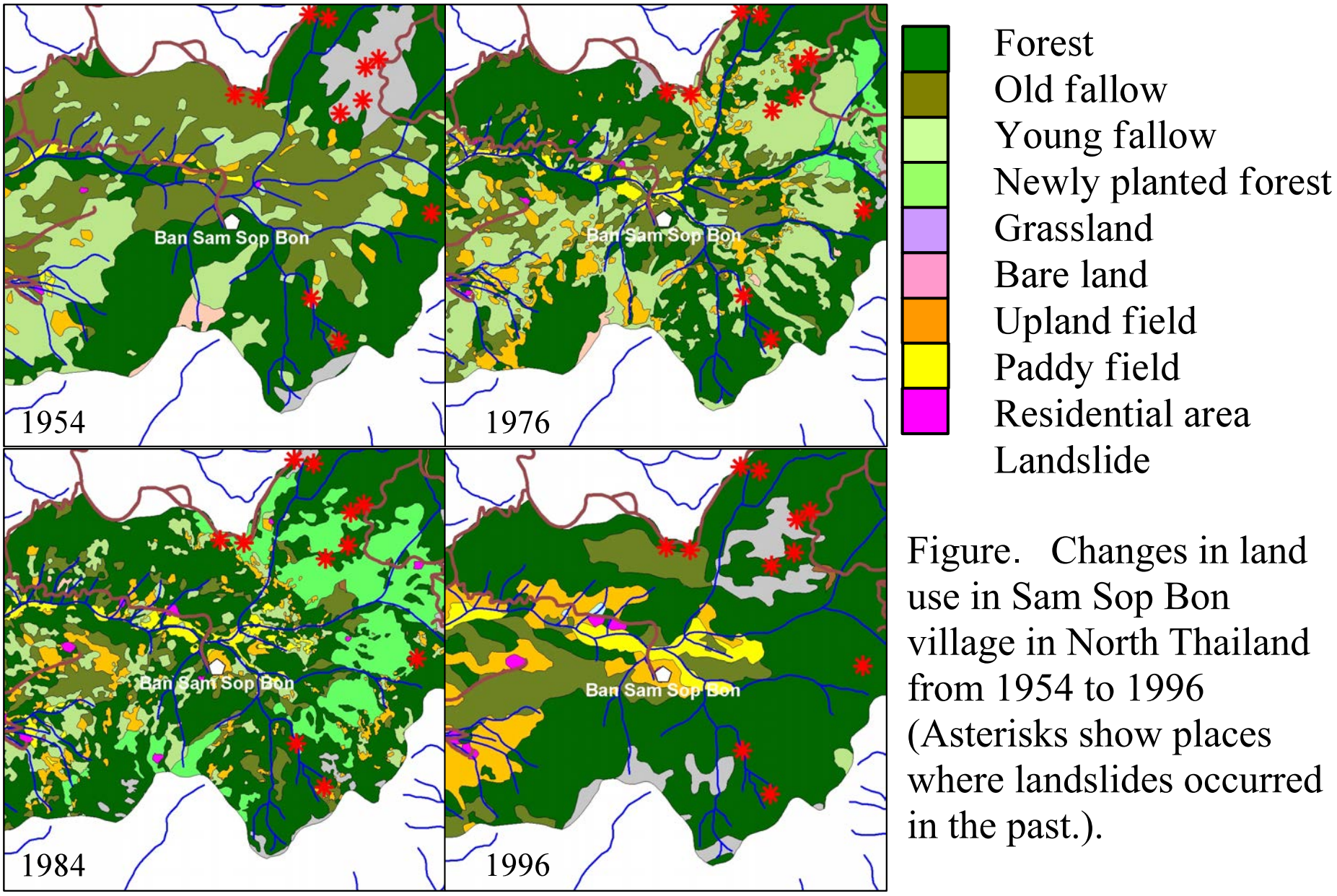


Figure. Changes in land use in Sam Sop Bon village in North Thailand from 1954 to 1996 (Asterisks show places where landslides occurred in the past.).

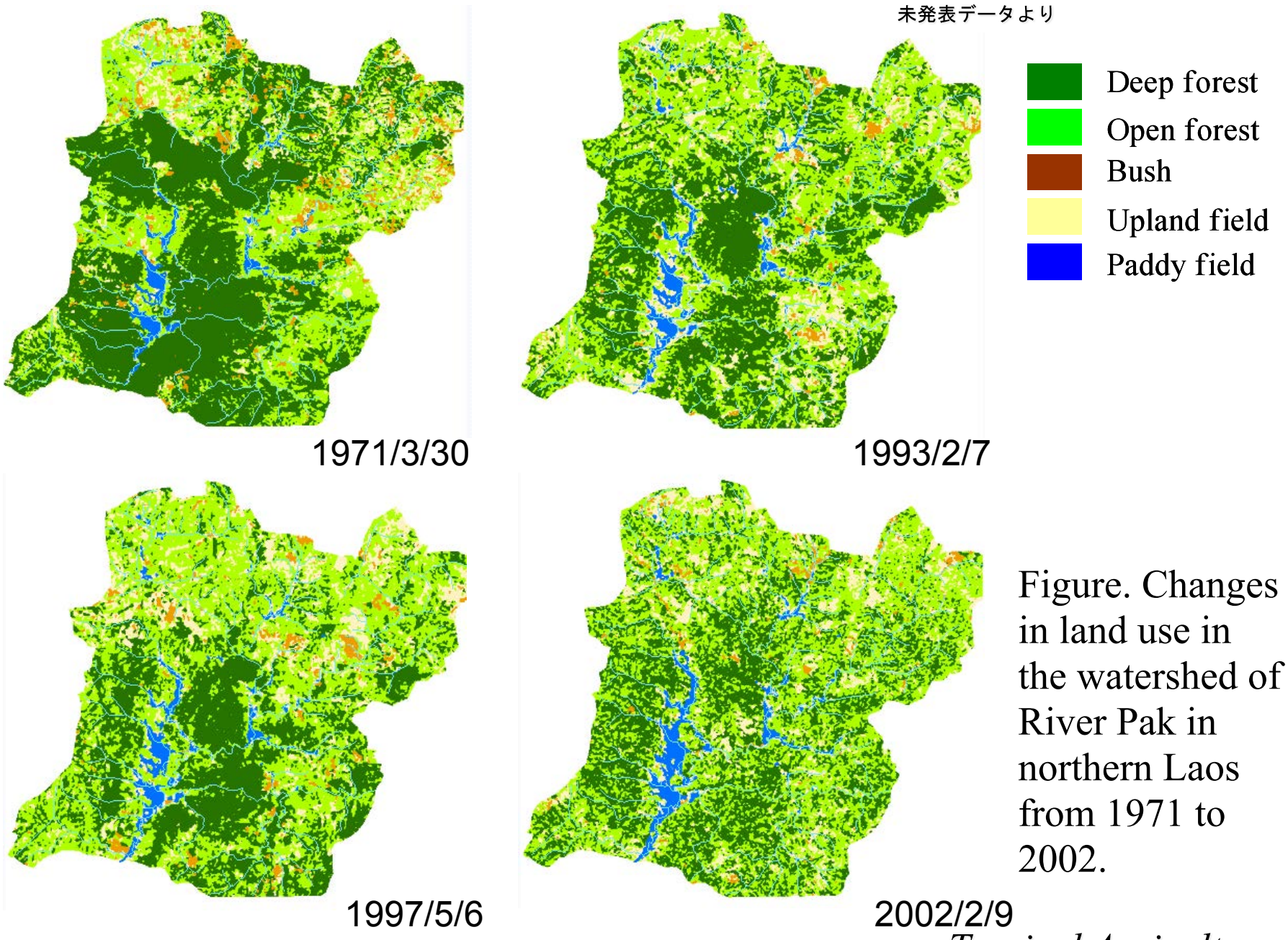
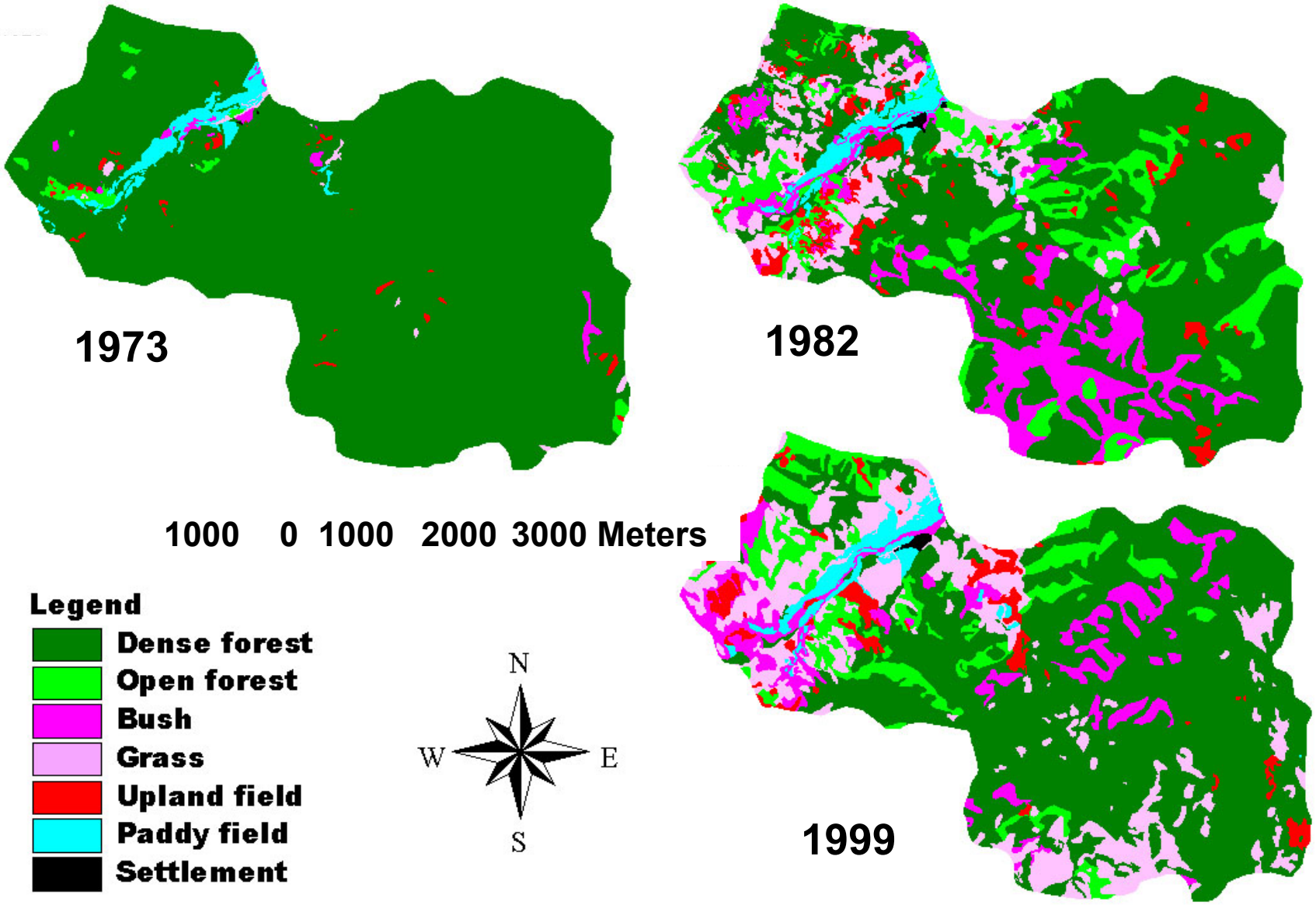


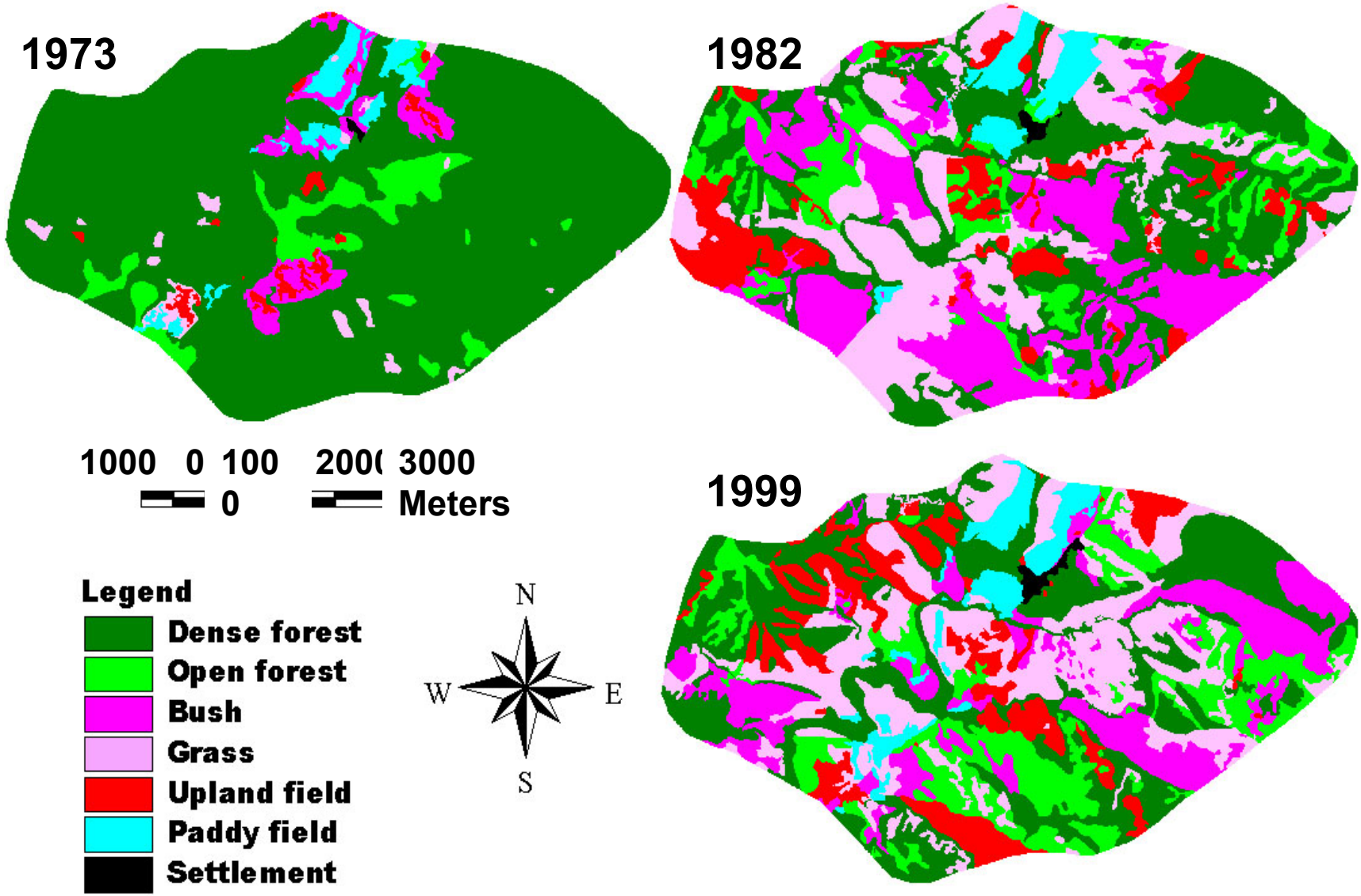
Figure. Changes in land use in the watershed of River Pak in northern Laos from 1971 to 2002.

Land use in Napa Tai village between 1973 and 1999



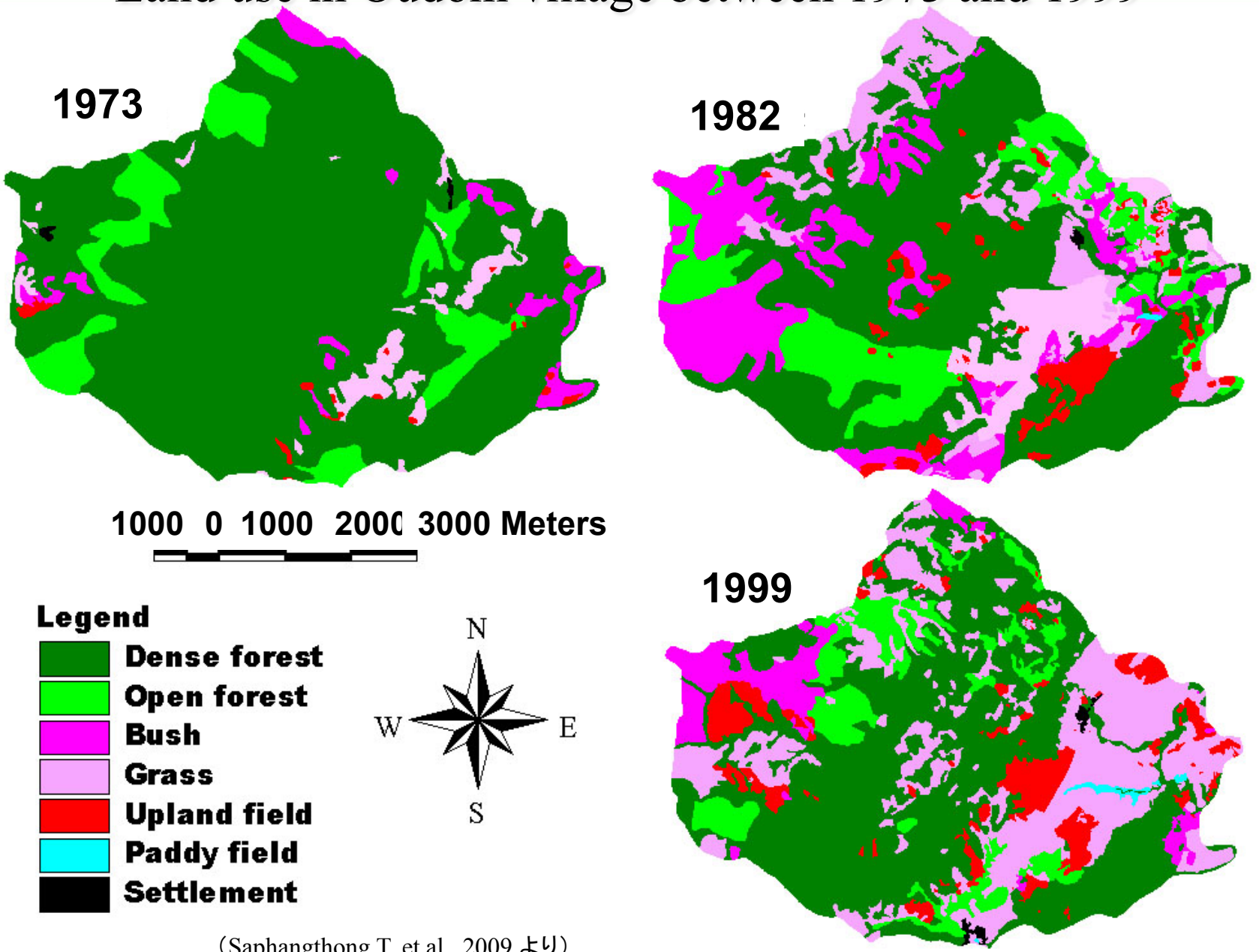
（Saphangthong T. et al., 2009 より）

Land use in Samkang village between 1973 and 1999



（Saphangthong T. et al., 2009 より）

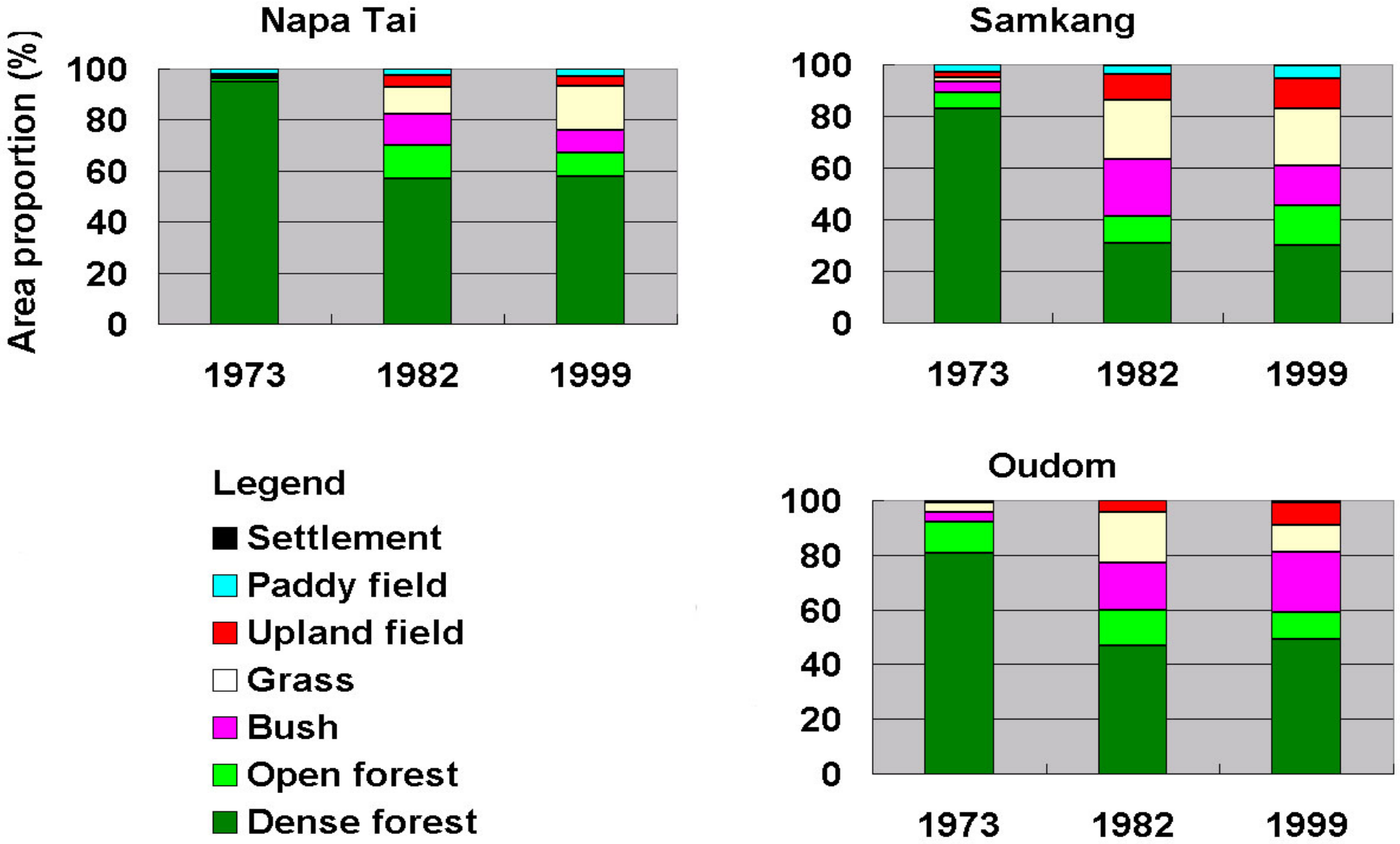
Land use in Oudom village between 1973 and 1999



（Saphangthong T. et al., 2009 より）

Changes in the composition of land use between 1973 and 1999

（Saphangthong T. et al., 2009 より）



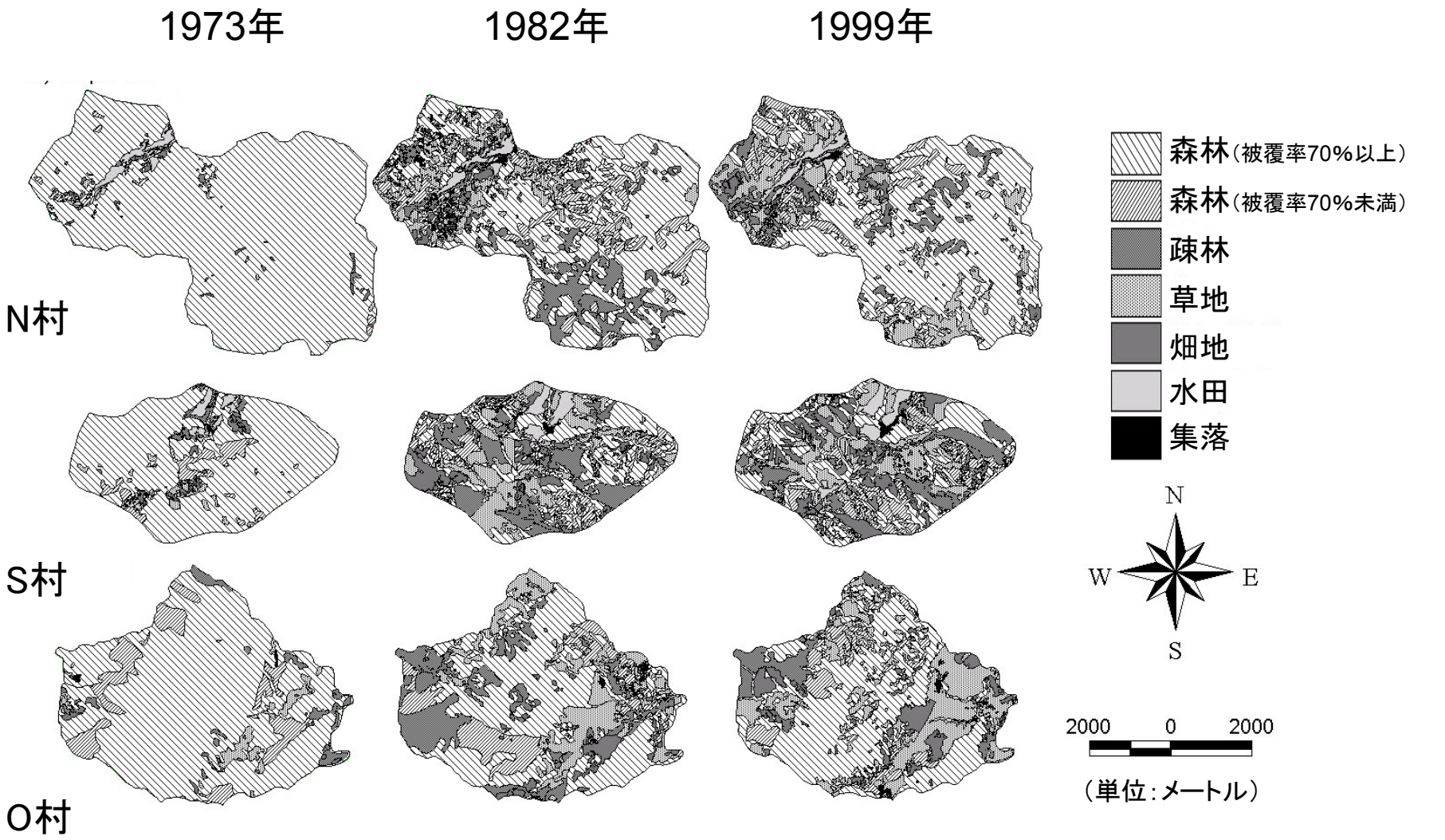


図　ラオス北部農村における過去30年間の土地被覆の変化

（Saphangthong T. et al., 2009 より）

Dynamics of land use and farming systems
(土地利用と営農動態)

１． Significance of agro- or agricultural ecology
(農業生態の意味)
２． Dynamics of land use in the tropics
(熱帯における土地利用動態)

３． Dynamics of farming systems
(熱帯における営農動態)

４． Methodologies of analysis (解析手法)

３． Dynamics of farming systems (熱帯における営農動態)

Farming systems (営農体系)

Relatively stable systems, which are managed based on agriculture, although including non-agricultural activities, generally by a household

Classification of farming systems by FAO

1. Irrigated agricultural system　2. Paddy based systems
3. Rainfed agriculture in humid areas
4. Rainfed agriculture in slope lands and dry highlands
5. Rainfed agriculture in arid or cool areas
6. Mixture of large scale commercial agriculture and small scale subsistence agriculture
7. Agro-fishery at coastal areas　8. Urban agriculture

Complex farming systems (複合的営農システム)

Classification of farming systems by FAO

Paddy based systems
  Combination with the second crop and fisheries
Rainfed agriculture in slope lands and dry highlands
  Combination with animal raising
Mixture of large scale commercial agriculture and small scale subsistence agriculture
Agro-fishery at coastal areas
Urban agriculture
  Suburban horticulture (近郊園芸) and subsistence agriculture
Agroforestry
Shifting cultivation (焼畑)

Cropping systems (作付体系)

Concept of time serial distribution of crops (Cropping sequence, 作付順序) united with aerial distribution of crops (Cropping pattern, 作付様式)

Sole cropping (単作)

Mixed cropping (混作)

Cropping system, in which multiple crops are planted in the same agricultural field

→ frequently observed in the tropics

Merits of mixed cropping (混作の長所)

1. Efficient use of resources (資源の有効利用)
   Solar radiation・water・soil nutrition
2. Diffusion of risks (危険分散)
   Agronomic and management riks
3. Complicate Agroecosystems
   Reduction in diseases and insects

Demerits of mixed cropping (混作の短所)

Existence of multiple crops (複数作物の存在) →

1. Difficulty of appropriate management (適正管理困難)
2. Difficulty of intensification (集約化困難)
3. Difficulty of mechanization (機械化困難)
4. Difficulty of large-scale production (大規模化困難)

Variety of mixed cropping (混作の種類)

1. Mixed cropping (混作)
2. Inter cropping (間作)
3. Mulch-layer cropping (混栽)
4. Agroforestry (アグロフォレストリー)

Agroforestry

Mixed cultivation of trees and herbaceous plants

Tree crops + herbaceous crops (annual, biennial and perennial crops)

Trees + herbaceous crops

Originally mixed cultivation of trees and crops

Landscape agroforestry (景観的ｱｸﾞﾛﾌｫﾚｽﾄﾘｰ)

Examples of complex cropping systems

Garden forests (屋敷林) and home gardens

Pekarangan (プカランガン)

Java, Indonesia

Many useful trees and herbaceous plants

Function of home garden

１． Agricultural functions

Food production, Production of non-food plant resources, Seed and seedling production,

Domestication, Experiments of new technologies

２． Ecological functions

Formation of pseudo-natural ecosystems, Maintenance of bio-diversity, Assistance of movement of organisms, resultant enlargement of habitats

３． Social and economic functions

Source of profit, Inheritance of indigenous knowledge (在来知) , Improvement of residence environment), Supply of Fire and charcoal wood

Sole and mixed cropping (単作と混作)

Traditional field crop production

→ Based on mixed cropping

Ex.: Shifting cultivation, Upland crop production in Deccan Plateau, Horticultural land

Intensification of agriculture

Introduction of cash crops → Shift to sole cropping

Present situation of upland crop production in the tropics

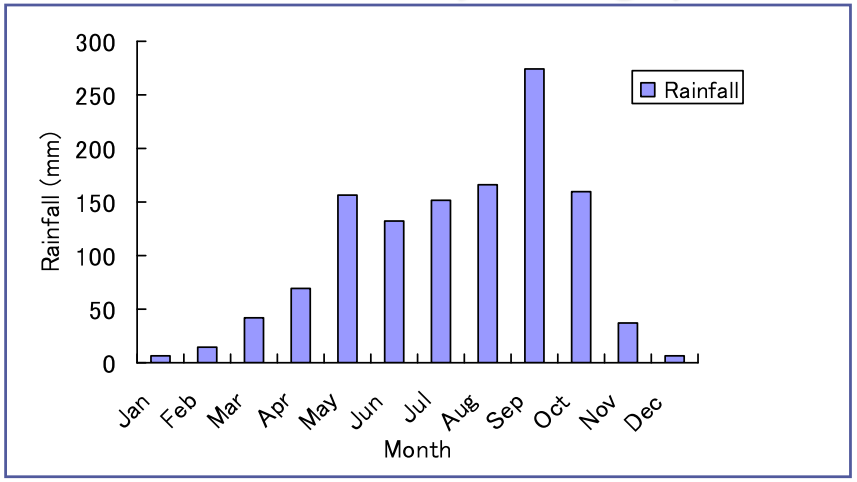
→ Increase in sole cropping

Paddy production

→ Sole cropping, traditionally combined with fisheries

Cropping systems of paddy rice

Chaophraya delta



Deep water rice ▪ Floating rice

Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

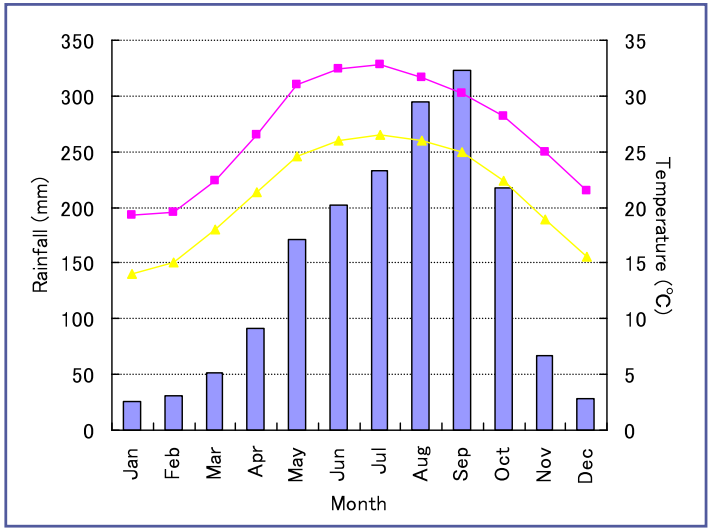
Dry season rice

Rainy season rice

Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

Dry season rice

The Red River Delta



Winter-Spring rice

Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

Summer rice

Winter-Spring rice

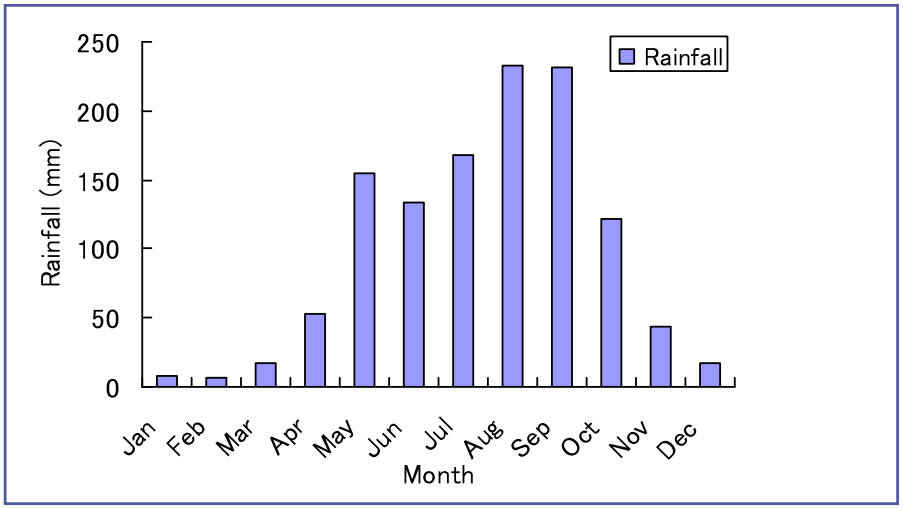
Summer rice

Winter crops

Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

Winter crops：vegetables, maize, Irish potato

Basins in Northern Thailand



Rainy season rice

Soybean

Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar.

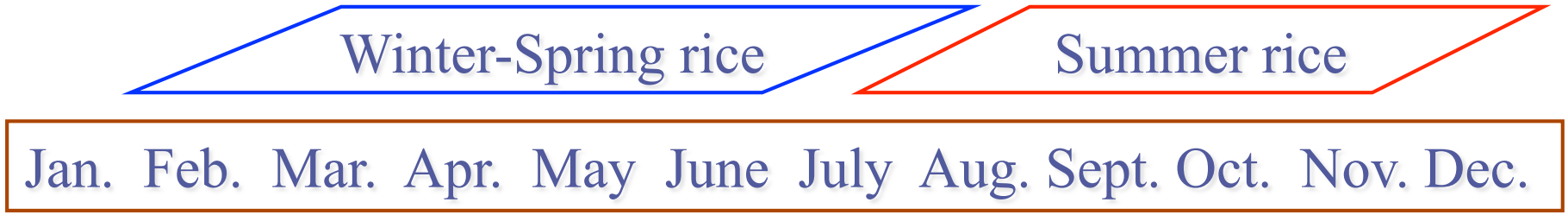
Rainy season rice

Garlic

Winter crops

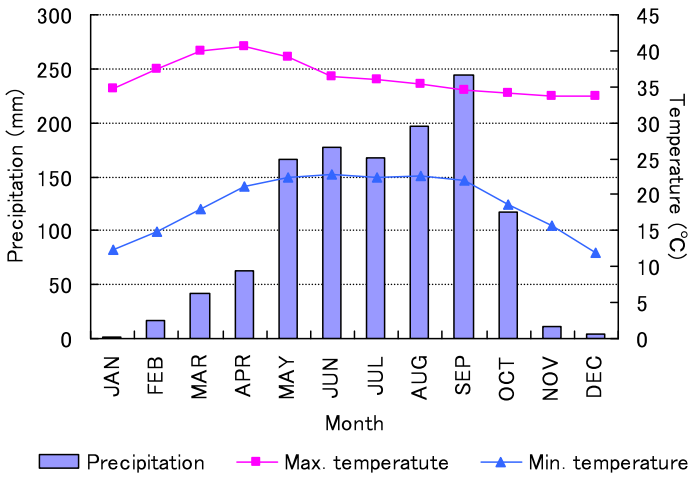
Winter crops : Vegetables, tobaco

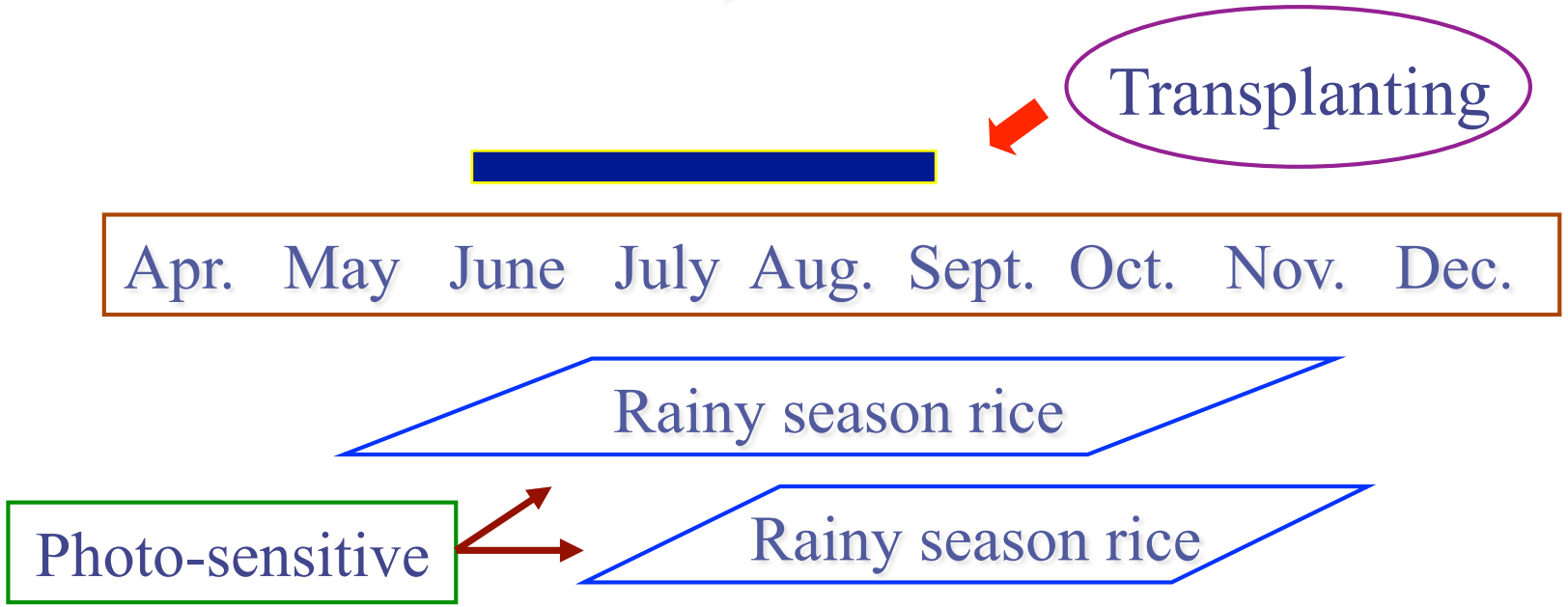
Montane area, Dien Bien Basin



Irrigation network, extension of direct seeding
(灌漑網・直播技術の普及)

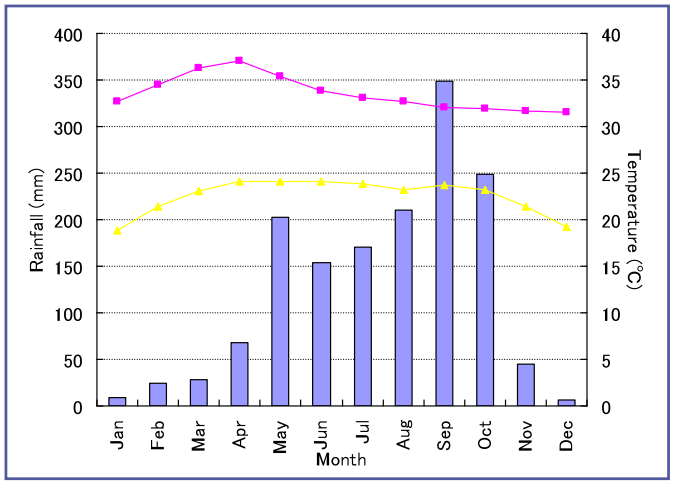
Plains, Cropping systems in rainfed paddy fields (Northeast Thailand)





Cropping systems of field crops

Central Thailand



Maize

Sorghum

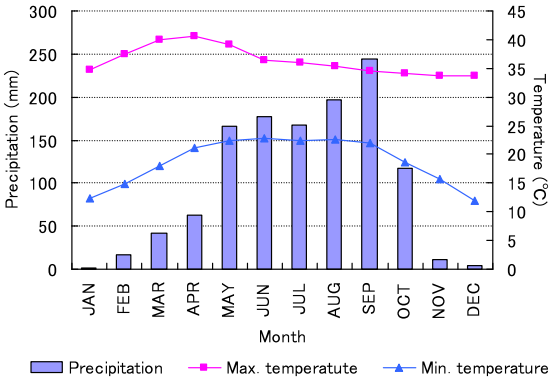
Apr. May June July Aug. Sept. Oct. Nov. Dec.

Maize

Mungbean

Sunflower

Northeast Thailand



Sugarcane

Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct.

Cassava

Cassava

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4. Methodologies of analysis (解析手法)

Methodologies of analysis（解析手法）

Collection of information (情報収集)

１. Field observation (観察)
２. Interviews (聞き取り調査)
３. Various statistics (統計資料の収集)
４. Remote sensing data (リモートセンシングデータの収集)

⇩

Analysis

Construction of database
Utilization of GIS (Geographic information systems)

Methodologies of analysis

1. Field observation
2. Interviews
3. Various statistics

⇩

Reliability of collected data

1. Observation → One moment
2. Interviews → Truth of answers of interviewees
3. Statistic data → Reliability

⇒ Mixture of multiple methods

Methodologies of analysis

1. Field observation
2. Interviews
3. Various statistics

⇩

Reliability of collected data

1. Observation → One moment
2. Interviews → Truth of answers of interviewees
3. Statistic data → Reliability

⇒ Mixture of multiple methods

Methodologies of analysis

（栽培システム学., 2005, p. 186より）

３. Various statistics

Statistic data	Contents	Organization	Web address
FAOSTATA	Agricultural data for past several years	FAO	http://apps.fao.org/default.jsp
World rice statistic	Various data on rice production	IRRI	http://www.irri.org/science/ricestat/index.asp
Agricultural statistics in each country	Detailed data at lower administrative levels	Statistic organization in each country	Homepage of each organization

Methodologies of analysis

（栽培システム学., 2005, p. 186より）

4. Remote sensing data

Name	Resolution	Range	Period
Satellite imagery			
CORONA	1.8-2.7 m	17x232 km, 14x189 km	1863～1972
LANDSAT 1-7	15-30 m	170x185 km	1972～
SPOT 1-5	10-20 m	60x60 km	1986～
JERS-1	18.3x24.2 m	75x75 km	1992～1998
IKONOS	1-4 m	11x11 km	1999～
ASTER	15-90 m	60x60 km	1999～
Aerial photograph	They depend on countries. Available at each country.		

Methodologies of analysis

（栽培システム学., 2005, p. 186より）

4. Remote sensing data

Title	入　手　先
Satellite imagery	
CORONA	http://edcsns17.cr.usgs.gov/EarthExplorer/
LANDSAT 1-7	http://edc.usgs.gov/, http://glcfapp.umiacs.umd.edu:8080/esdi/index.jsp etc.
SPOT 1-5	http://www.spotimage.fr/ etc.
JERS-1	http://www.eoc.jaxa.jp/
IKONOS	http://www.spaceimaging.co.jp etc.
ASTER	http://www.dgs.aster.ersdac.or.jp/gds_www2002/index_j.html

Methodologies of analysis

Collection of information (情報収集)

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４．Remote sensing data (リモートセンシングデータの収集)

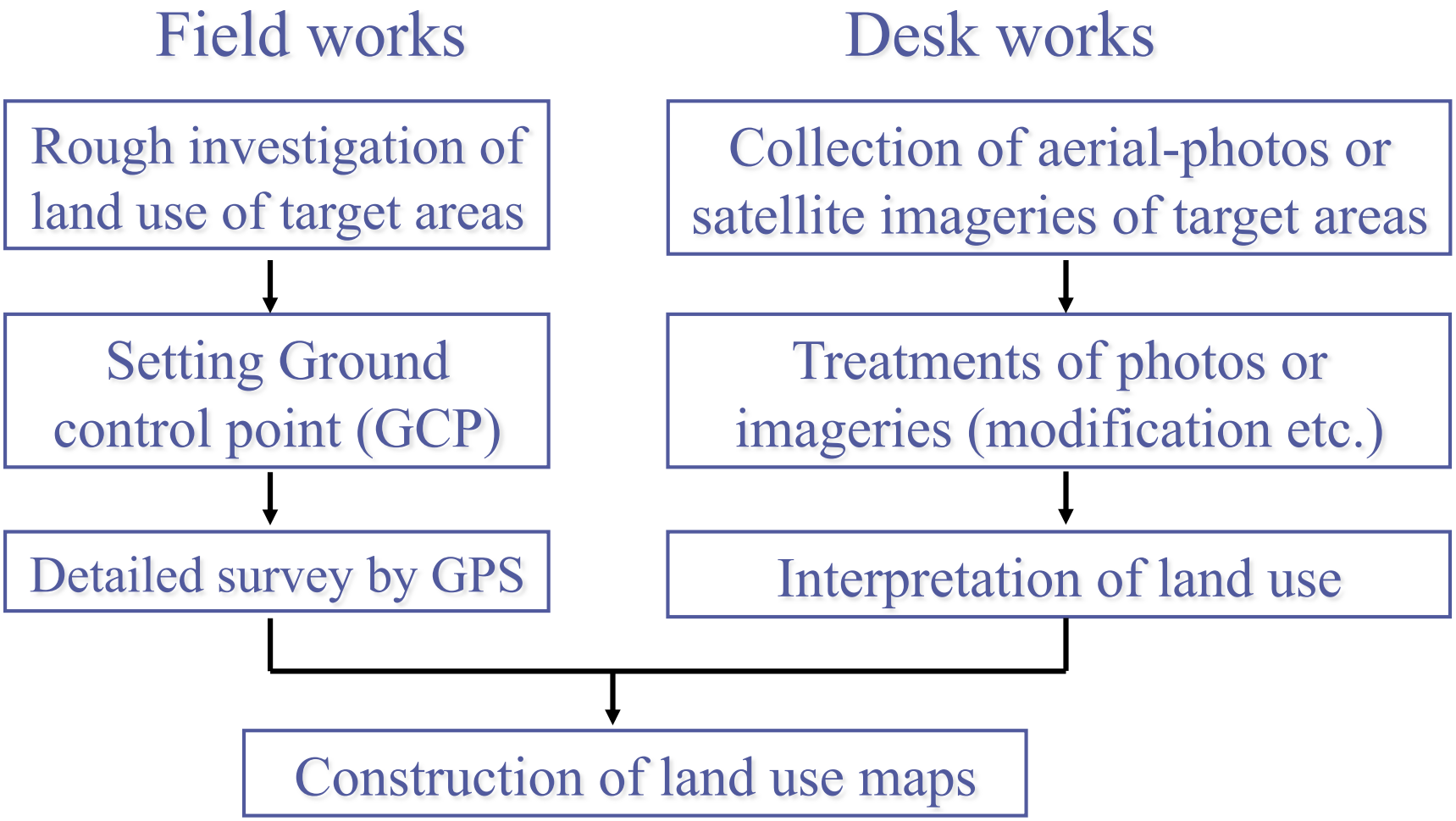
EXCEL
Database software
(ACCESS, File Maker)

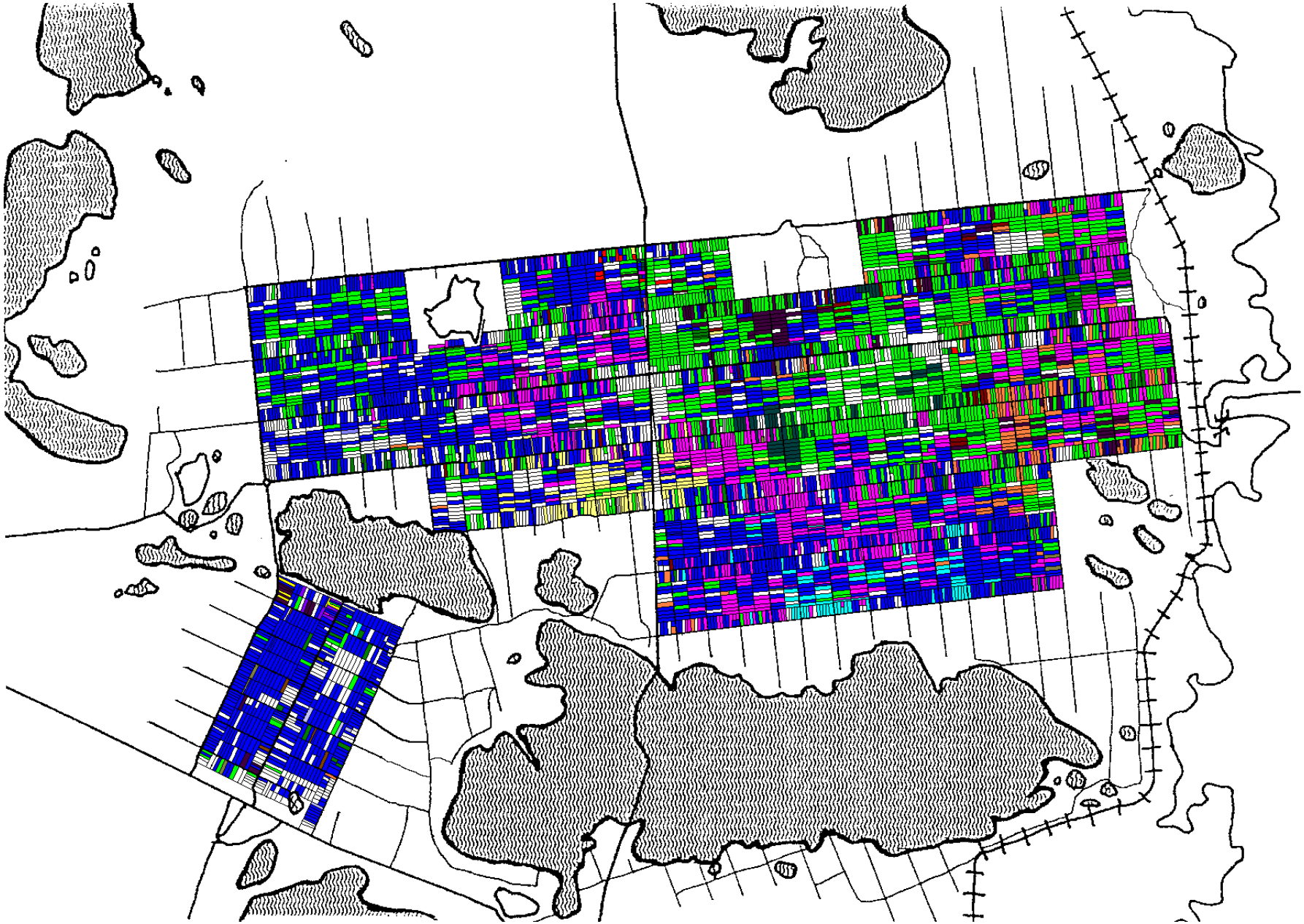
Analysis

Construction of database
Utilization of GIS (Geographic information systems)

Methodologies of analysis

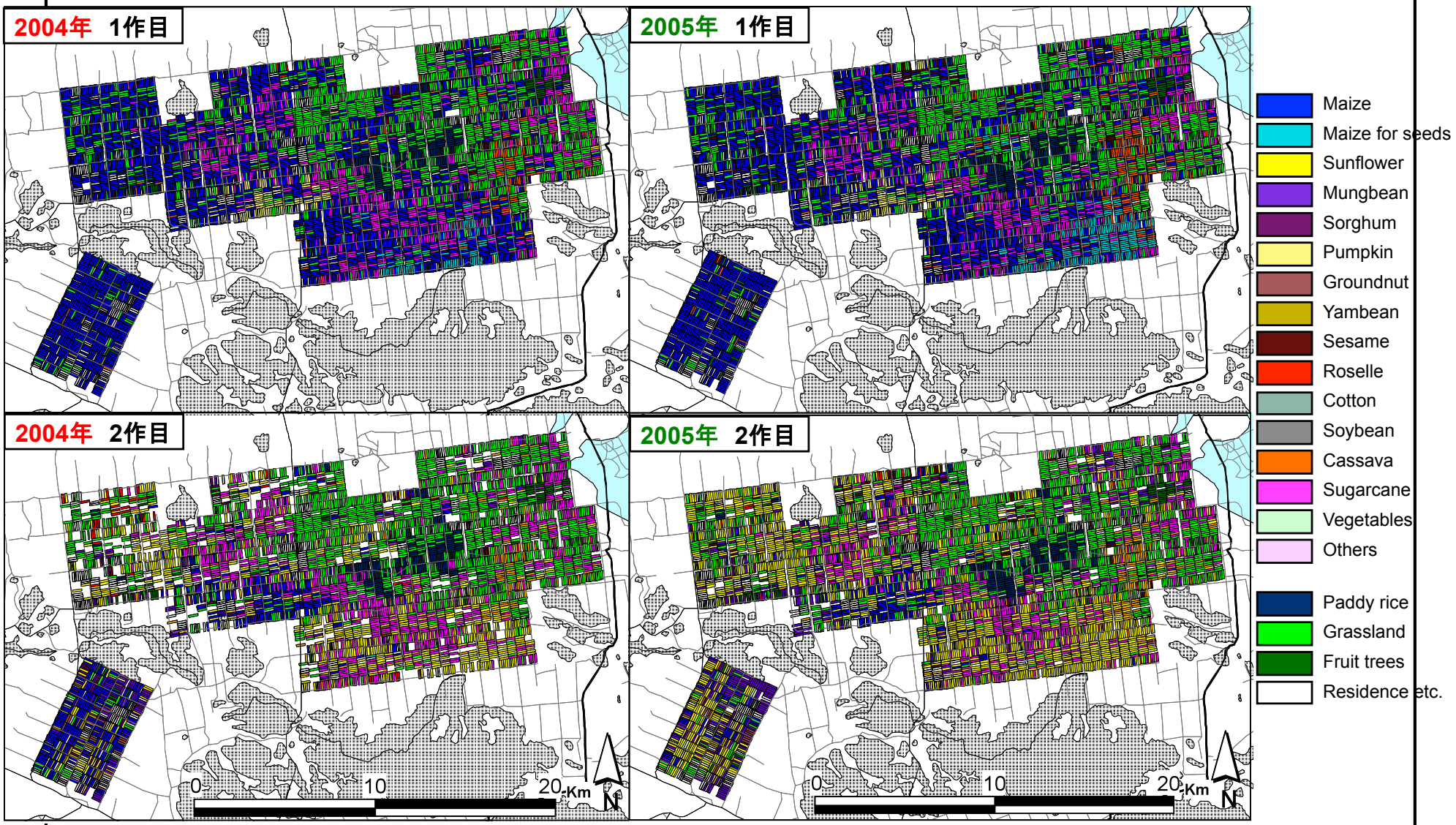
How to make land use maps





Rainfall : 791mm Cropping system : 50

Rainfall : 1107mm Cropping system : 55



Tropical agricultural ecology
(熱帯農業生態学特論)

Diversified agricultural resources

1. Climate

   Air temperature, Solar radiation, photoperiods, Precipitation

2. Land

   Soil and Topography

3. Organisms

   Vegetation, Flora (植物相), Fauna (動物相)
   Microorganisms, Bio-diversity (生物多様性)

4. Human resources

   Race (人種) , Ethnicity (民族), Population (人口)

Changes in agricultural resources

１． Climatic changes (気候変動)

a. Short-term and middle or long-term changes

b. Causes of changes (変動因)

Changes in solar activities

Changes in the number of Sunspot (太陽黒点)
(about 11-year cycle)

Volcanic eruption, Meteorite (隕石),
“Nuclear winter” (核の冬)

Greenhouse gas (CO_2, methane etc.)

Heat island　Rise in air temp and increase in rain

1. Climatic changes

c. Influences of climatic changes on agriculture

Global cooling

Reduction in productivity, related to cooling
Next glacial period (ice age)
Serious reduction in productivity

1. Climatic changes

c. Influences of climatic changes on agriculture

Global warming

Increase in CO_2 emission by increased respiratory activities of organisms

Increase in productivity in the short run

Reduction in productivity by increased respiratory activities as air temperature rise continues

Yield reduction by the acceleration of maturation

Qualitative effects of low temperature deficiency on plant growth

Reduction in agricultural land

Coastal lowland (rise of sea surface, enlargement of saline area)

Changes in Agricultural resources

２． land resources

Soil deterioration, Desertification, Weathering

a. Short-term and middle or long-term changes

b. Causes of changes (変動因)

Elapse of time

Climatic changes

Anthropogenic factors (人為的変動因)

Agricultural development (農業開発)

Residential or Industrial d. (宅地・産業開発)

Disappearance of natural vegetation

Changes in Agricultural resources

３． Bioresources

Plant resources

Natural vegetation or forests

⇒ Important for stabilizing local ecosystems

Increase in artificial ecosystems (agricultural or urban ecosystems)

⇒ Increase in vulnerability of local ecosystems

⇒ Quantitative and qualitative reduction in plant resources

Animal resources

Closely related to plant resources

Causes of changes: Climatic changes, Changes in land resources, Anthropogenic factors