Participatory GIS for Joint Management of Protected Areas: Cases of Doi Phu Kha National Park, Thailand

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Abstract

This article analyzes the efficiency of a different implementation of Geographic Information Systems (GIS) from the conventional usage. These are geographic information systems which are based on a participatory process called Participatory GIS (PGIS). This article explains the principles and functions of Participatory GIS which reliably expresses both the spatial display (geographical condition) as well as the indigenous spatial knowledge (ISK), by which these are related to the mental map of people, and social, cultural, and economic conditions that affect resource utilization in corresponding places through geo-spatial information management tools. This article clarifies the process of Participatory GIS through the project of Joint Management of Protected Areas (JoMPAs) at Doi Phu Kha National Park, Nan Province, Thailand. This project was an action research for development which employed Participatory GIS process for spatial use zone demarcation by multi-stakeholders. This approach, therefore, leads to a joint management agreement which is reliable and is a sustainable solution for natural resource and environment problems.

Keywords: Participatory GIS, mental map, spatial display, indigenous spatial knowledge

I. Introduction

The northern area of Thailand consists of a mountainous area with steep slopes and high elevation. It is the source of the major rivers in Thailand, and comprises rich forest resources and ecosystems. Moreover, it provides a home for hill tribe people who settled more than 200 years ago, and have engaged in traditional farming. On the other hand, these areas are the focus of serious concern to the government for national resource conservation. Therefore, government declared the need for preservation and conservation of natural resources and environment by designating Protected Areas (PA). In Thailand, these areas are declared without participation of local communities who have lived there for a very long time.

The highlands of northern Thailand are an example of a contradictory situation arising when a centralised government system extends its control to remote areas and clashes with traditional cultivation practices. On the government side, in terms of policy, there are conflicting interests between forest preservation on the one hand, and the integration of ethnic minorities on the other (Puginier, O., 2002). The main focus of policy lies on the restoration of forest cover. On the other hand, hill tribes, which are pioneers, are characterized by the practice of agriculture with traditional farming systems, and modification, in order to explore other alternatives to secure livelihood. These issues have become one of mediation and conflict resolution in order to overcome the dichotomy between forest protection and local agricultural systems. Nowadays, such areas are managed by the state, which has the right of prohibition and arrest. The rules of protection

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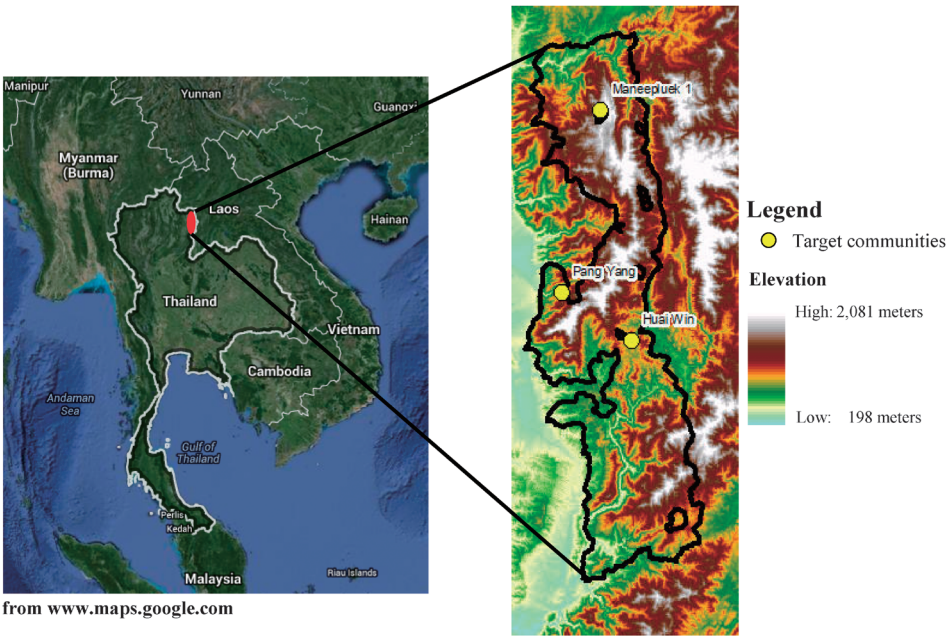

from www.maps.google.com

Fig. 1 Location of Doi Phu Kha National Park, Nan Province, Thailand

in these areas are used for law enforcement to resolve conflicts between local communities and forestry agencies.

Doi Phu Kha National Park, Nan Province (Fig. 1), covering 1,065,000 rai, or 170,400 ha, is experiencing such conflicts as stated above. It was declared as such by the Thai government in 1999, and is a typical remote mountainous area and an important region on the upper reach of the Nan River, one of main four rivers of northern Thailand. The area is inhabited by a population of hill tribes, composing 48 villages of 2 main ethnic groups, Lua and Hmong. As current problems in PA, the communities were settled in these areas long before the establishment of National Park. At the time, there was no clear information on land use patterns of local communities. Consequently, conflicts arose between the communities and the park authority.

The project of Joint Management of Protected Area (JoMPA), which was supported by DANIDA, was established between 2006 and 2009 and extended until 2011. The objective of the project was to preserve biodiversity and ecosystem functions of the protected areas. They should be preserved with joint responsibility and should benefit from sustainable management operated by all involved people and stakeholders. In order to solve land use problems in highland areas, the demarcation process of the special use zone was set up. It contributed to a negotiation platform for several stakeholders, including members of the target village, members of neighboring villages, local authorities, forestry agencies, park authorities, local government officials and all local stakeholders.

Special use zone demarcation process was one of important operations of JoMPA which was supported by Participatory GIS process. Participatory GIS employed the process of collection, management, analysis, and display of spatial data. One of the important factors was geographic information, which explains physical and land use conditions of hill tribe communities, integrated high and low geographic technology e.g. mapping technology, Geographical Information Systems (GIS), Remote Sensing (RS), and Global Positioning System (GPS). This information technology was crucial for implementation of the project. The process provided the geographic data, helping villagers and park staff to understand

the information as maps and 3D-models, and helping the villagers, park staffs and all stakeholders to reach agreement on the land uses of specific areas. The maps and other geographic information were important parts of the joint management agreements between the villages and the park.

II. Framework of Participatory GIS

Participatory Geographic Information Systems or Participatory GIS (PGIS) may be a term which is not yet well known or understood. Therefore, when we define this term, we may understand 2 meanings; GIS processes and participation approaches.

1. GIS as a Tool of Geography

A Geographic Information Systems or GIS, one of the efficient information technologies, is understood within the traditional framework as a tool for making maps. GIS is a computer-based tool for mapping and analyzing spatially referenced data, and allows integration of disparate layers of information into a common spatial database, whether the data are related to an explicit geographical reference (e.g. latitude/longitude or grid coordinates), or related to an implicit reference (e.g. a place name, road, environmental feature) (Quan, J., Oudwater, N., Pender, J. and Martin, A., 2001).

GIS's operation is based on the ability of the computer to store, manage, analyze, and display geographic or spatial data. It is a complex information technology beginning with the digital representation of landscapes or geospatial data. However, the acquisition of geographic information is involved with advanced and modern technology; Global Positioning System (GPS), Remote Sensing (RS) (e.g. Ariel photo, satellite imagery), mapping technology (e.g. photogrammetry, DEM creation, RIDAR). These data can be applied in widely various fields because of distinct properties in spatial dimension of phenomena in the real world; locations, distances and directions.

Actually, GIS is a more powerful and useful information system than the conventional description in the short term. The most prominent efficiency of GIS can be demonstrated in spatial analysis which has different characteristics from other information technology. GIS has several technical advantages in this regard. For example, it is able to collect, manage, query, and analyze data with GIS software on a computer base. It handles geo-referenced spatial data, which conforms to academic and scientific principles. It maps out spatial data to several dynamic scales. Its display is simple to create a thematic map representing integrated data, both spatial and non-spatial (e.g. socio-economic data, population data, cultural data etc.).

It can clearly answer spatial dimension questions; for instance, how many agricultural areas are there in a province? How many entertainment venues are located in distance 500 meters around a school? Which locations are suitable for landfill of garbage in a municipality district? GIS helps us to clearly understand with spatial answers to these questions, by which it is benefitted from spatial analysis functions that are supported by spatial data. Moreover, it can contribute to decision-making in on-the-ground activities of developments and can lead to short or long term action plans for spatial solutions.

2. Participatory Approach and GIS

Participatory Research Methods (PRM) and Geographic Information Systems (GIS) have been recognized independently over the past 20 years for their contributions to planning more sustainable forms of development (McConchie, J. A. and McKinnon, J. M., 2002). It started in the late 1980s and went through great changes in the 90s with the diffusion of modern spatial information technologies including GIS, low-cost GPS, remote sensing imagery and its analyzing software, open access to data via the internet and steadily decreasing cost of computer hardware.

Participatory GIS may be easily described as the process of participatory creation and map using which is based on interpretation of data or resource ownership. Accordingly, Participatory GIS is the integration of local knowledge and stakeholders' perspectives in the GIS (Quan, J. *et al.*, 2001). Therefore it is the result of a spontaneous merger of the

process of Participatory Learning and Action (PLA) methods with Geographic Information Technology and Systems (GIT&S). PGIS practice, therefore, is based on using geo-spatial information management tools (Rambaldi and *etc.*, 2006, McCall, Michael, K., 2004).

We can therefore understand that GIS is not merely considered to be a system of map creation by computer. It can be integrated with participatory approaches in order to create geo-spatial information of owner of data in more and deeper dimensions. Moreover, it can create maps which are correct by the academic principle of mapping, and reliably represent geo-spatial data from the real world within the principles of science or modern Information Technology (IT), which is the important property of GIS. Basic analysis of spatial dimensions (i.e. location, distance, area, size, volume, distribution and slope) then can be precisely answered. Therefore people who work in these approaches are necessarily required to have knowledge of geography theory. They should understand in geography theory the properties and limitations of spatial data: that it is integrated between knowledge and method of GIS processing for example; map coordinate systems, map projections, mappings, scales, vector data (i.e. contour line, road, and river etc.), and raster data (i.e. DEM, aerial photo, and satellite imagery etc.).

3. Spatial Perception and Indigenous Spatial Knowledge

Another important aspect of Participatory GIS is the process of spatial display or visualization. Tungprasert, S. *et al.* (2002) interpreted from the book "Rediscovering Geography: New Relevance for Science and Society" and noted that spatial display is closely linked to the core concepts of space i.e. location, region, distribution, spatial relationship, scale and change. These are displayed with spatial information which is blended from display process and spatial data, and its purpose is to clearly illustrate the spatial dimension. Consequently, these properties contribute greatly to the reliability of this process.

In addition to this, spatial display also resembles the spatial perception of people, which leads to an understanding of hidden dimensions. Pongprayun, C. (2003) identified that humans have a sense of place at the local level. A human life binds into a place which is a residence or an original habitat and constructs a sense of cherishing. Personal realization is bound in the place which effects the geographic perception of humans, and allows the inhabitant to comprehend the meaning of that place. In particular, spatial perception is a method which attempts to create that comprehension. Mental map, which is the image of humans in spatial perception, is a representative of this comprehension.

Mental map is the result of spatial display or visualization processes which link to particular perception and comprehension of humans regarding place. Mental map can display the mental arrangement of images of desirable residential and assessment knowledge about a location. Moreover mental map is a mechanism which extends to knowledge about their behavior in environment, as well as being a method of usage of environmental knowledge which reflects their behavior in an area. Consequently, it constructs the rich knowledge of their area. From the advance of information technology, in the present, this process is also developed and displayed in digital pattern or computer base, which has contributed management and display processing in more dynamic formats and with fewer restrictions.

Mental map is similar to the results of spatial perception of humans by which it is related to personal experience about environment in their habitants. It constructs a set of special knowledge which differs from other areas, as well as communicating through historic story or meaning of members in their group about use and tenure in resource and environment. This creates the bond to their place, where feeling is constructed and embodied in the inhabitant.

These processes attempt to understand and explain indigenous spatial knowledge (ISK) of people which has significant characteristics. ISK is the integrated information collected from local people regarding their usage of land and other resources. It has an aspect of spatial concept of local people for the management of

their land. All members of a community usually share the same perception in ISK, and they have often handed down ISK through oral history and folklore. This tends to be neglected by outsiders because it is not considered accurate, precise or scientific. Sometimes, it is hard for the community itself to utilize ISK to predict coming situations when the community is subject to changeable multi-conditional influence.

ISK is similar to information which is developed from deep observation of the relationship between people and their land or resources. Local communities usually refer to experience in the usage for their resources. Therefore they are the owner of this ISK which is similar to science systems for management of their land by themselves. Especially, a function of area in land ownership is overlapped by, for instance, areas of agriculture, food, healthcare, conservation or resource management (Minage, P. and McCall, M., 2006).

Therefore spatial perception of humans is closely related to local knowledge. It is this integration which expresses their special identity, and is usually communicated by the accounts of community members from the past to the present. This is represented by the conditions or situation of their usage which reflects culture, tradition, belief, socio-economy and regulation. The characteristics of this knowledge are communicated with spatial display tools which affect different implementation from general or traditional GIS.

4. Geo-spatial Information Management Tools

This approach differs from traditional implementation of GIS by which it usually likens an implementation from top to down. While Participatory GIS approach employs GIS in deeper dimension than general GIS, it empowers local management. In particularly, Participatory GIS is usually used for identification of the control and access to resources, and the usage in spatial or resource data of owner knowledge (Minage, P. and Mccall, M., 2006). Moreover it is sometimes used for conservation or protection of traditional knowledge from outside forces or authorities

According to the definition of Participatory GIS, it is the integrated processes between Participatory Learning and Action (PLA) and Geographic Information Technology and System (GIT&S). Therefore, this approach constructs geo-spatial information management tools as shown in Fig. 2 (e.g. sketch map, field survey map, participatory 3D model, low-cost GPS, remote sensing imagery, GIS mapping) (Rambaldi, G. *et al.*, 2006). They are aimed to display ISK which simplifies interpretation and comprehension. These geo-spatial information management tools are important in supporting the process of spatial learning, discussion, negotiation, information exchange, analysis, advocacy, and decision making among insiders of the community and outsiders.

However, explanation of ISK is usually neglected because it is not communicated in a format which is reliable and provable. Usually, it is not accurate, precise, or scientific. Therefore, once we display again a set of ISK by which it is referred to geo-coordinate systems (geo-referencing), this ISK is more reliable as it is corrected from spatial data properties in GIS processes. Community, consequently, can clearly communicate information in their area which is accepted better by outsiders. Geo-referencing process of ISK is sometimes a contribution of the balance between the insider's form and format of presentation of the problem in question, and the outsider's authority or economic force (Rambaldi, G. *et al.*, 2006).

Participatory GIS employs GIS in a different dimension from the traditional pattern. There are 2 aspects which are integrated; horizontal and vertical dimensions. The first dimension is the process of spatial display or visualization which reliably and clearly presents geographic or physical conditions of the area. It may be displayed by geo-spatial information management tools (Fig. 2). The other dimensions was the process of data presentation which is related to interaction between the spatial condition and the usage of the owner in resources by which this is reflected from contents of tradition, culture, regulation, socio-economy, state policy etc. Therefore Participatory GIS enables efficacious processes or tools for presentation

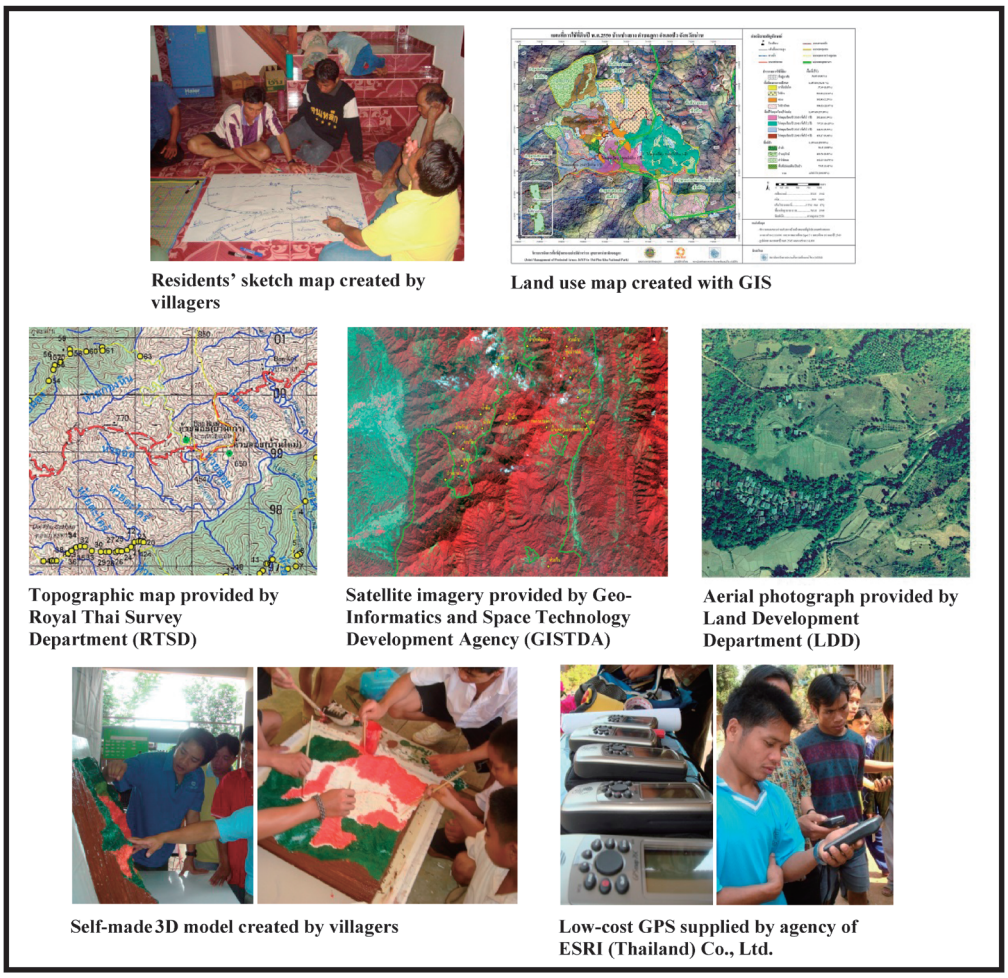

Fig. 2 Examples of geo-spatial information management tools

between spatial display (geographic condition) which is geo-referenced and ISK (Fig. 3). This process constructs the same level of comprehension of stakeholders between insiders (i.e. members of community etc.) and outsiders (i.e. neighbor community, researcher, state official etc.).

In important aspects, implementation of Participatory GIS consists of the steps of operation which lead to efficiency of process. That is participatory method which allows all stakeholders for joint management of resources by which it should construct cooperation to have the same comprehension. The creation of comprehension among all stakeholders is not simple in practice because it has hidden complication of problems. Therefore, it is necessary that we have the tools which allow understanding from different angles. This is the contribution to participation of all of stakeholders in problem solution (Tan-kim-yong, U. *et al.*, 1994).

Participatory GIS is sometimes part of the supported process for Participatory Land Use Planning (PLP). Hence, it is a process involving local people and stakeholders in the joint management and development of forest and land resources with support by GIMTs. This process to strengthen local organization can lead to the establishment of local community organizations for managing forest and land use. The information and communication systems that are the key to participatory

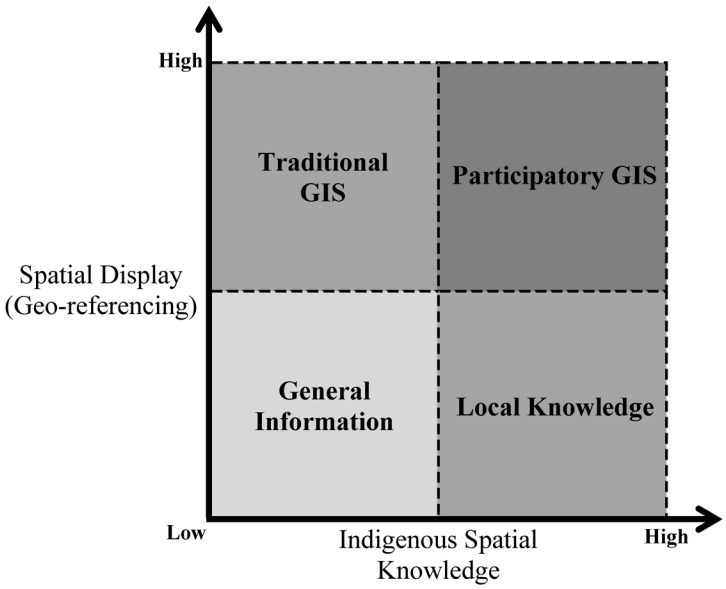

Fig. 3 Characteristics of participatory GIS (PGIS)

decision-making demand that all parties have equal access to information. The integrated process of PGIS in PLP leads to the application of reliable solutions on natural resources and environment problems from all relevant users and stakeholders.

III. A case of PGIS for Joint Management of National Park

1. Challenges at Doi Phu Kha National Park

From the problems of highland area in Thailand, JoMPA project had set up objectives to preserve biodiversity and ecosystem functions of the protected areas. Furthermore, it should be preserved from a joint level of responsibility and benefit with sustainable management practiced by all involved people and stakeholders. Meanwhile, these are based on comprehension of local knowledge of hill tribe people, such as land use pattern, tradition, culture, belief, which they reflect by their behavior in land activities.

The study area, Doi Phu Kha National Park, is one of the protected areas in Thailand, and is also residence of hill tribes who have special land use patterns in the forest. From the recent situation of problem, local communities have lived in protected areas of state by which they have subsistence agricultural system that was nature-based. Moreover, several factors have influenced changes of agricultural patterns to more intensive agricultural patterns among the hill tribes, for instance, high population growth rates in hill tribe communities, introduction of commercial agriculture, nature-conservation policy of the government, and more convenient infrastructure. Consequently, they have modified their practices and are searching for alternatives for a more stable livelihood. These activities were restricted by national park controlled by law. The distinct issue, therefore, is the conflict between the livelihood of local community and policy of state that occurs from the lack of participation from many sectors. These have led to misunderstanding between the duty of local government officers and local villagers' activities in the protected area.

The approach of land use demarcation was instituted in order to solve problems from the lack of participation from joint management in protected area. PGIS was employed for demarcation process of special use zone which clearly identified community boundary and current land use of communities classified, namely agriculture area (i.e. permanent,

Table 1 Processes of PGIS in JoMPA

Processes	GIMTs	Actors	Outputs
1. Finding community information	Sketch map Topographic map (1 : 50,000)	Members of communities JoMPA's researcher	ISK of communities Mental map of villagers
2. Field surveying —Community boundary	Low-cost GPS Topographic map (extend from 1 : 50,000 to 1 : 10,000)	Committees of communities All neighboring communities Park authorities Local government officials JoMPA's researcher	The explicit community boundary which was accepted by all neighboring communities
—Land use systems	Low-cost GPS Satellite image Ortho Aerial photo (1 : 4,000)	Members of target communities JoMPA's researcher	Conditions of current land use patterns and their territory
3. Negotiation platform (setting in community level)	Sketch map 3D model GIS community land use map	Committees and members of communities All neighboring communities Park authorities Local government officials All local stakeholders JoMPA's researcher	The agreements of —The explicit current land use system and community boundary —The regulations on their land use
4. Land use monitoring systems —Community levels	GIS community land use map Low-cost GPS 3D model	Committees and members of community	Monitoring systems on community boundary and regulation on land use between communities and national park
—National Park levels	GIS land use map which covers whole NP Low-cost GPS	Park authorities	

rotated, and abandoned area), conservation forest, multipurpose forest, cemetery forest. It is, therefore, necessary that these areas are accepted by all stakeholders in the area including construction of regulations in their land use which concerned the limitations of usage in their land use area. PGIS, especially, was an important process to support the land use demarcation process as shown in Table 1.

The important thing in order to succeed in this process is a negotiation stage which was the creation of the agreements on land use systems and regulations of local communities from all stakeholders including members of the target village, members of neighboring villages, local authorities, forestry agencies, park authorities, local government officials, and all local stakeholders (i.e. consulted committees of national park). Likewise it is a process involving local people and stakeholders in the joint management and development of forest and land resources with support by geo-spatial information management tools. This process to strengthen local organization can lead to the establishment of local community organizations for managing forest and land use.

As a result of this process, villagers were able to clearly understand the boundary of their land use area, for instance current cultivated field, rotated field, conservation forest, multipurpose forest and cemetery, and clarify the rules of the community concerning the limitations of usage in their land use area. In some outputs, they were more willing to change their activities and land use patterns and more willing to work with the park officials in joint management of the resources, if given greater opportunities for livelihood.

2. Process of Demarcating Special Use Zone

Demarcation of special use zone was one of the most important processes of JoMPA. This process was classified into 4 steps. The first step was introduction of JoMPA among community members and other stakeholders to strengthen community and establish community committees by finding local information for the project to prepare for GIMTs. The scenes of the first step are shown in Photo 1 and 2. The collected basic data of community comprised the history of settlement, the past and present land use patterns, the situation of current land/resource use, the socio-economic conditions, and the territory of the community. Prepared GIMTs were composed of both high- and low-technology-based ones such as digital topographic map (to a scale of 1 : 50,000), satellite imagery (of SPOT5 with resolution 10 meters), digital ortho-aerial photos (scaled corresponding to a cadastral map of 1 : 4,000), low-cost GPS and GIS software (ArcGIS version 9.1).

This process was also essential to improve human capacity in geographic technology and knowledge for both national park officials (e.g. in map reading, map coordinate, GPS, remote sensing, GIS) and representatives of communities (e.g. in map reading, map coordinate, GPS, 3D model creation). The enhanced capacity of involved people helped the operation of joint management. Moreover, it facilitated establishment or reorganization of community committees as the representatives of communities were responsible for planning, controlling and monitoring their land use and resource management followed by regulations. The scenes of training and workshop are shown in Photo 3–6.

In step 2, field surveys were conducted to scrutinize both community boundary and current land use systems. GIMTs were used, as in step 1, for the field surveys in which all stakeholders participated together as shown in Photo 7–10: namely committees of communities, all neighboring communities, park authorities, local government officials, JoMPA's researchers. As a result of this operation, villager could clearly recognize the community boundary and the territory of their land use area as well as clearly understand the community regulations concerning the limitations of usage in their land, which were expressed by GIS land use map.

Step 3 was the negotiation platform. This process provided all stakeholders with geographic data in GIMTs, helping villagers and park officials to share the same information by use of GIS land use maps and 3D models which gave actual information from field surveys. It allowed all stakeholders to reach an agreement on land use systems and their regulations. The negotiation platform leading to the acceptance of community boundary, land use systems and regulations is shown in Photo 11–14.

The final step was the creation of monitoring systems on community land use systems and regulations. These monitoring systems were composed of community and park levels by which it expressed the control, prevention, and conservation of accepted land use. Therefore, they were efficient monitoring systems enabling cooperation between park authorities and local communities. GITs also supported the monitoring systems which provided the same information in both 2 levels.

As shown in Fig. 4, the park authorities started annual surveying for land use monitoring when they found encroached area after checking it's coordinate with GPS receiver and GIS land use map. If that area is located in responsible boundary of local community, it was informed to community committees in order to recheck the encroached area with GPS receiver and GIS land use map. There are two cases for management by community. Firstly, it enforces their regulations by community committees. Consequently, it is reported to head of authorities and head of national park for acknowledgement at community level. Secondly, community do not enforce their regulations in some cases, for instance when it is enforced by neighboring communities, outside people or capitalists. It is reported to park authorities in order to enforce by law of national park. This information is annually reported for acknowledgement in land use management to the Office of Conservation Administration Area 13th, which is an organization to control these

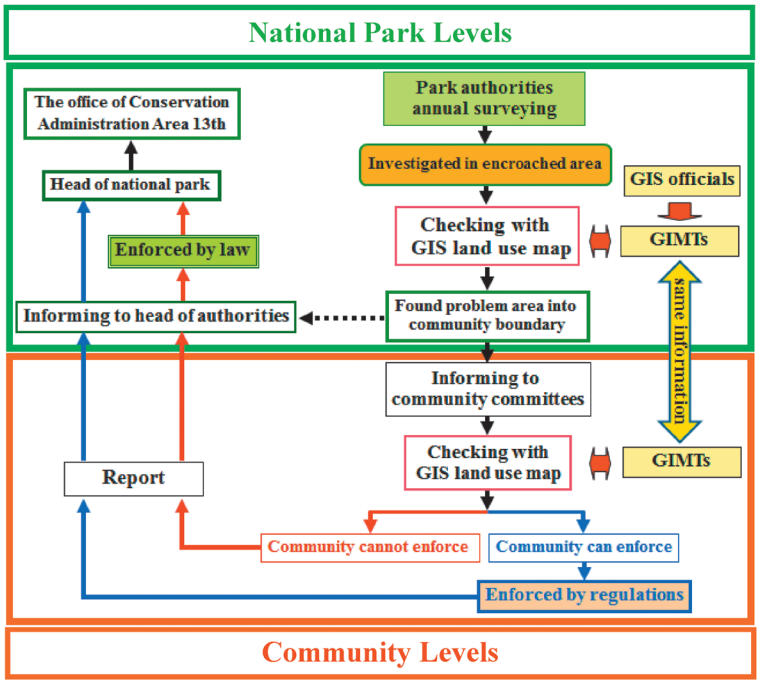

Fig. 4. Integrated land use monitoring system between community and national park levels

Table 2 Different outputs of implementation of PGIS on special use zone demarcation at representative 3 communities

Processes	Huai Win	Pang Yang	Maneepluek 1
Participation from all members of community	High level	High level	Low level
Introducing and finding JoMPA information	Very good response	Good response	Good response
Field surveying of —Community boundary —Land use systems and their territory	 Clearly Clearly	 Clearly Vague some area for commercial crop	 Unclear in some places Unclear in some places
Negotiation platform on land use systems and their regulations	—Same understanding from all members of community —Accepted from all members and stakeholders	—Same understanding from all members of community —Accepted from all members and stakeholders	—Unclear agreements in some area —Some members did not follow their regulations
Land use monitoring systems —Community levels —National Park levels	High level of strength —Absolutely, can enforce by regulations Can be linked with community	Middle level of strength —Can enforce by regulations in some cases Can be linked with community	Low level of strength —Cannot enforce regulations Difficult to link with community
The level of successful implementation on the process of special use zone demarcation	High level	Middle level	Low level

protected areas. This operation, therefore, was able to solve the conflicts which arose from misunderstanding between national park and local community with a joint management approach.

IV. Implementation of PGIS at Representative Communities

Huai Win, Pang Yang, and Maneepluek 1 were selected to represent all hill tribe communities in Doi Phu Kha national park: Huai Win is Lua, Pang Yang is also Lua, and Maneepluek 1 is Hmong. From recent changes in agricultural land use patterns of these communities, there are several drivers which have influenced agricultural patterns of the hill tribes, for example, high population growth rates, introduction of commercial agriculture, nature-conservation policy of the government, more convenient infrastructure, including climate change situations which are not only global issues but also local impacts that these communities are facing. These, consequently, are reflected by success of the process of special use zone demarcation at several levels of local communities (Hemwan, P., 2013). Table 2 expresses the different outputs of PGIS implementation in three representative communities.

1. Case of Huai Win

Huai Win, representative of a subsistence cultivation community, is characterized by simple land use pattern. Therefore, the community boundary was clearly identified from the agreement of neighboring communities and local stakeholders. There is efficient land use demarcation and regulations of their land use management which have been created and are strictly controlled by community committee, and followed by the members.

All processes of land use demarcation have been participated by villagers of Huai Win. The community boundary and current land use system were clearly surveyed in the whole area of community. This process was simple to identify because their agricultural patterns were not complex while the community boundary was small in area covering 1,091 ha (residence area is 12 ha; agricultural area is 521 ha; forest area is 558 ha). Upland rice was still a main crop for annual cultivation, and they have rotated area (*Rai Lao*) for 7-year-rotated cultivation which was clearly identified. The commercial crop of corn has increased little because of inconvenient access. Therefore, negotiation platform on land use systems and regulations were clearly accepted by members of community and all local stakeholders.

For the land use monitoring systems, this community had an efficient process which was enforced by regulations with their community committees. As in 2009, there was a case of conservation forest encroachment by a member, which the community committee could manage the problem by their regulations among themselves. Moreover, if they had the case that community could not manage by their regulations, they would be able to link to national park in order to control or enforce by law in their area at higher levels of land use management. These reflect that the efficiency of land use monitoring systems has been enhanced, with links between the regulation of local community and the law of national park.

2. Case of Pang Yang

Pang Yang, a semi-commercial cultivation community, has faced some changes from high population growth rates, commercial agriculture, and more convenient infrastructures. These factors allowed change from subsistence cultivation to more commercial cultivation. Consequently, the agricultural patterns of this community were more complex than Huai Win because they received technology and innovation from outside due to the location of this community, which is near and has great access to a thriving city. The case of Pang Yang, therefore, reflects the adaptation of farmers in recent periods of change.

Currently, Pang Yang land use amounts to 725 ha (residence area is 6 ha; agricultural area is 531 ha; forest area is 188 ha) as well as *Rai Lao*, but rotation period was reduced to 5 years because of increasing population and the pressure from neighboring community. Corn was the main commercial crop which had been introduced and became the main household income of this community. Therefore, in

some areas of community, corn area (88 ha) has been prepared for almost all members of the community. Some activities of these cash crop cultivations on this area, which trended to higher usage of herbicide and insecticide, were directly affecting their neighboring communities. Hence, this situation resulted in some difficulties in the demarcation process between agricultural area (cash crop) and forest area.

The negotiation platform on land use systems and regulations of Pang Yang were intensively discussed from Srila Pet community (northern Thais) which is a neighboring community and settled at lower altitude than Pang Yang. They were affected by the corn area of Pang Yang which is located above the water source area of Srila Pet. The restriction of corn area was joint creation from Srila Pet, the affected community. Consequently, the regulations of Pang Yang were more complex than Huai Win due to greater complexity of the agricultural patterns.

For the land use monitoring systems, this community had less efficiency than Huai Win because of its more complex agricultural patterns, and there was pressure from neighboring communities which were impacted by their cultivation. The boundary and regulation in some areas where there is an overlap of the land between subsistence and commercial crops were still unclear. This community could manage on land use monitoring by their regulations as well as being able to link to national park authority for land use management because they still have good relationship with the national park. Moreover, the location of land is easily accessed for monitoring survey by park authorities.

3. Case of Maneepluek 1

Maneepluek 1, a commercial cultivation community, has the most intensive agricultural systems and the most complex land use patterns among 3 representative communities. Because they have had very large boundary of land use; 7,097 ha (residence area is 28 ha; agricultural area is 1,334 ha; forest area is 5,735 ha), it is difficult to define the boundary in some areas which are hard to access. Due to economic reasons of Hmong farmers, they usually preferred to extend cultivated land for cash crops and short-term cultivation of vegetables (i.e. corn, cabbage, ginger, persimmon).

The land use demarcation process of this community, consequently, was the least efficient among the 3 cases of representative communities. Community boundary and land use territory of Maneepluek 1 were unclear in some places because of the extended land use territory. For the land use regulations, they have unclear understanding of the length of time of unused periods of abandoned area (*Rai Rang*) which is usually agreed at between 1–7 years. Because some households have occupied *Rai Rang* which are left more than 7 years, the land was stolen to return to cultivation in that area.

Therefore, the regulations of this community were more complex, and more subtle than in 2 other communities because of the greater complexity of agricultural patterns and social relations. For the negotiation platform on land use systems and regulations, intensive discussions were held by members of the community and all stakeholders. Because Hmong people are typical immigrants from several different areas, this community is composed of various groups of relatives, as they usually keep benefits within kin of each group. It is difficult to communicate information to all members in this community. Consequently, community committees, who were selected by representative from each group of relatives, were less efficient in enforcement of land use regulations toward some members of community.

These factors affected the land use monitoring systems, hence this community was less efficient than Huai Win and Pang Yang. As was the case in 2009, there were 5 cases of violations which encroached into the communal forest in Maneepluek 1's land use boundary.

National park authority still was not able to link to land use monitoring in this community. One of the reasons was due to bad experience in the past between national park and Hmong community. This community frequently had conflicts over land use problems of unclear boundary and these usually led to violence. However, PGIS process of special use zone demarcation in JoMPA has much reduced these

conflicts from the past because it initiates land use information which is created from the joint management approach.

V. Concluding Remarks

Participatory GIS (PGIS) have integrated GIS processes and participation approaches and is considered the process of participatory creation and map using which is based on interpretation of data or resource owner. Therefore, it is the result of a spontaneous merging of the process of Participatory Learning and Action methods with GIS. The important aspect of PGIS is spatial display which is closely linked to the core concepts of space and local knowledge. Spatial display is liked to spatial perception of people which is linked to mental map in each person. Mental map is representative of comprehension with a sense of the place of people at the local level. It, therefore, is the result of spatial display or visualization processes which link to spatial perception on the place of humans as well as being related to specific knowledge of personal experience about environment in their habitats.

PGIS attempts to understand and explain indigenous spatial knowledge (ISK) of people. The weak characteristic of ISK is that it is usually neglected by outsiders because it is not accurate, precise, or scientific. These are compensated by distinctive property of GIS which is the operation of geo-referenced spatial data, and is correct by academic and scientific principles. Therefore, spatial perception of humans is closely related with ISK which is represented from condition or situation of their usage which reflects culture, tradition, belief, socio-economy, and regulation.

The characteristics of this knowledge can be communicated with Geo-spatial Information Management Tools (GITs). This approach constructs spatial tools with the purpose of displaying ISK for simple comprehension, for instance sketch map, field survey map, participatory 3D model, low-cost GSP, satellite image, GIS mapping. These support the process of spatial learning, discussion, negotiation, information exchange, analysis, advocacy, and decision-making among insiders of the community and outsiders. These are processes involving local people and stakeholders in the joint management and development of forest and land resources with supporting by GITs. The information and communication systems that are the key to participatory decision-making demand that all parties have equal access to information. The PGIS process is able to be applied as a reliable solution to natural resources and environment problems from all relevant users and stakeholders.

The demarcation process of special use zones employed the PGIS process to operate joint management in protected area. PGIS, therefore, was employed for these processes to clearly identify community boundary and current land use of communities. It is necessary that these areas were accepted by all stakeholders in the area including construction of regulations in their land use which concerned the limitations of usage in their land use area. It was expressed through a methodology composed of 4 steps.

First steps were introducing and finding information for JoMPA including preparation among GITs, the strengthened community, and the establishment of community committees. Moreover, capacity building in geographic technology and knowledge was set for both national park officials and representatives of communities. The second steps were field surveying of both community boundary and current land use systems. The third steps were setting the negotiation platform for villagers, park officials, and all stakeholders by using GIS land use maps and 3D models to understand the same information. And the final steps were creation of monitoring systems on community land use systems and regulations at both national park and community level.

The successful PGIS implementation of the demarcation process of the special use zone is reflected from agricultural land use patterns and socio-economic situation of differences of local representative communities. Huai Win is representative of a less adaptable community. Due to difficulty of access from outside, they did not receive development aid from the government or economic influences. Consequently, they have efficient land use de-

marcation and regulations of management due to simple agricultural system. The monitoring systems of their land use had efficient process which was enforced by regulations with their community committees, as they were also able to link to national park in order to control or enforce by law in their area at higher levels of land use management.

For the case of Pang Yang, they are a community which has had continuous adaptation. They have faced some changes due to multiple factors which resulted in adaptation from subsistence cultivation to more commercial cultivation. Therefore, they have higher complexity of commercial crop patterns and they have pressure from neighboring communities due to their infringing cash crop area. This then resulted in intense negotiation platform on land use systems and regulations of Pang Yang and the affected neighboring community. The monitoring systems on land use were also less efficient than Huai Win because the boundary and regulation of land use in some areas were still unclear.

Finally, Maneepluek 1 is representative of a commercial community. They have the most intensive and complicated land use patterns. Their land use area covers a very large boundary and it was difficult to define the boundary in some areas where access to land was difficult. Consequently, community boundary and land use territory, as well as land use management were unclear in some places because of the large number of relatives in this community. This shows that the regulations were less efficient as they were not enforced for all members by community committees. These also resulted in less efficient land use monitoring systems relative to Huai Win and Pang Yang.

This study observes that communities which were able to adapt with efficient land use management are at the same time able to support the sustainability of their livelihood. From the issue, the question is how best to encourage communities which are conducting more stable livelihood from their cultivation to have more efficient land use management as well. Pang Yang, the semi-commercial cultivation communities, is continuously adapting to all influences. Pang Yang displays suitable practice for effectiveness of land use planning. They have analyzed and oriented themselves for adaptation to choose alternative cultivation which is more stable and effective.

Pang Yang is a community which adapted from subsistence cultivation or nature-base cultivation to semi-commercial cultivation. They initially developed agricultural land from upland rice which has low efficiency and were then influenced by physical conditions to adopt terrace paddy as the land is near their residence. The terrace paddy is the result of alternative of stable cultivation as it requires less labor while giving higher yields, but they have to prepare the high land irrigation system. Therefore, they have increased forest area for water source by reviving the agricultural land for upland rice in water source area of community to be multipurpose forest which is 73 rai in 2009, and 169 rai in 2012 from 30 farmers. These reflected that the balancing system is a development of both stable livelihoods and sustainable ecosystems in protected area with joint management approach.

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Photo 1. Local meeting for informing target community and setting up community committees

Photo 2. Finding basic data of a community by interview with villagers

Photo 3. Park officials learning how to use GPS and read coordinates on a map

Photo 4. Villagers building a 3D model covering their community area

Photo 5. Villagers learning how to read coordinates on a map

Photo 6. Villagers learning how to use GPS in the field

Photo 7. Villagers, neighboring communities and local authorities surveying community boundary

Photo 8. Local authorities surveying and demarcating community boundary

Photo 9. Villagers surveying current land use system with JoMPA's researcher

Photo 10. Using topographic maps, ortho-aerial photos and satellite imagery in the field survey

Photo 11. Negotiation platform set up at the community level

Photo 12. 3D model and GIS land use map were tools for supporting negotiation platform

Photo 13. Participants checking data on GIS land use map

Photo 14. Acceptance of land use boundary and regulations by members of community and all other stakeholders