Relief Models, a Multipurpose Tool for Improved Natural Resource Management

The Experience of the Upper Nan Watershed Management Project in Thailand

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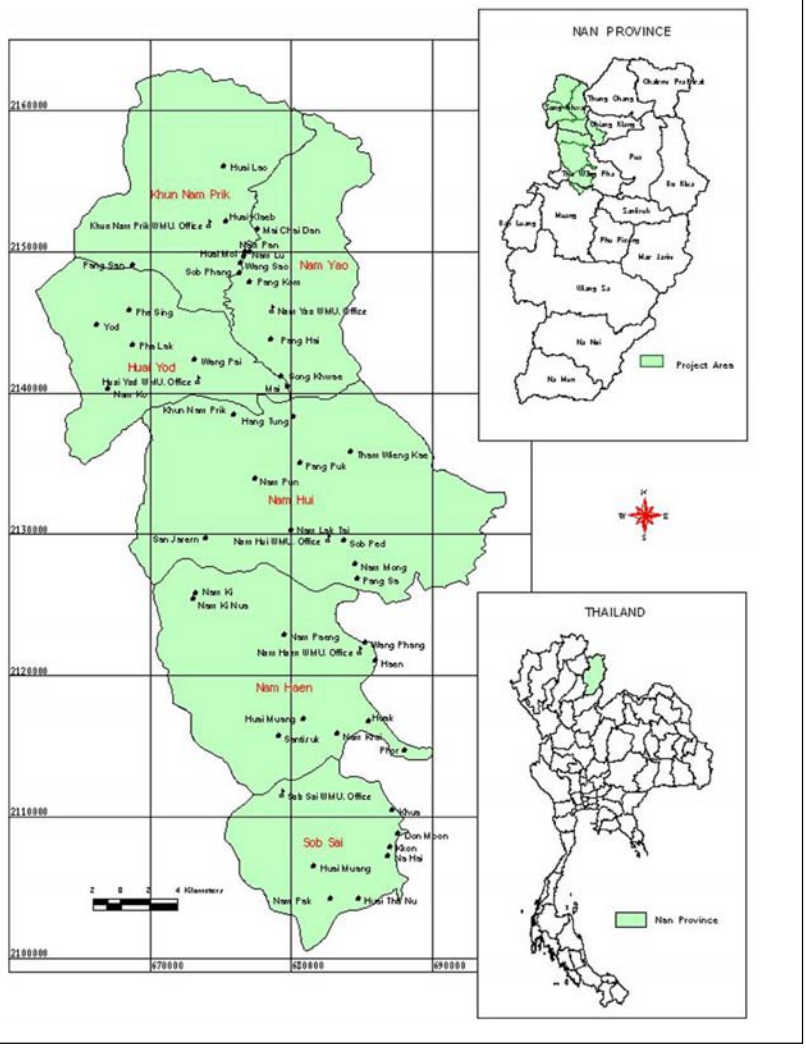
Background

The use of three dimensional topographic models (3-D models) in the context of participatory watershed management in northern Thailand had its origin in the Doi Sam Muen (DSM) Highland Development Project (HDP). From 1987 to 1994, the Royal Forest Department (RFD) implemented the intervention in Chiang Mai Province with technical assistance provided by the Chiang Mai University and financial back-up by the Ford Foundation and the United Nations Drug Control Program (UNDCP). The DSM-HDP was an integrated highland development intervention tailored to reduce opium cultivation among Karen, Lisu, Hmong, Lahu, Yunnanese, Shan and Northern Thai peoples on an area of about 2,200 km^2 in highlands located at elevations ranging from 1,000 to 2,000 m a.s.l. .

The experience gained by the DSM-HDP in using 3-D models served as the basis for the Thai-German Highland Development Project (TG-HDP) in developing the Community-based Land Use Planning and Local Watershed Management (CLM) social forestry approach (Jantakad and Carson, 1998). In both projects community organisers and villagers worked together to assemble 3-D topographic models representing their villages' land area. The scale used was 1:10,000. These models were considered to be powerful and important as they served a common language for the people involved, many from different cultures. They were coloured with information relevant to land use and updated every year (Limchoowong, 1995).

The successful practice of relief modelling, which was carried over from these two projects to the Upper Nan Watershed Management Project (UNWMP) as consultants - who previously worked in the DSM-HDP - contributed to its conceptualization and design. To respond at best to the recommendations made in the project design, the UNWMP recruited - at its onset - eight staff who had previously worked on the Doi Sam Muen Project. Nonetheless, the process had to be tailored to new social and ecological circumstances. While 70% of the UNWMP area is classified as National Forest Reserve, its agro-climatic and physical characteristics differ from those of the Doi Sam Mun Project. In fact, while the latter was operating at higher elevations, the UNWNP is confined to

Watershed Management Unit Boundaries and Villages in Project Area



lower altitudes (300 to 500 meters a.s.l.) not suitable for opium production. In addition, most villages are accessible via all weather roads.

The UNWP (1996-2003) is implemented by the Royal Forest Department (RFD) with financial support provided by the Danish International Development Assistance (DANIDA). Its objective is to achieve sustainable management of the natural resources by government agencies and local communities. The project is located in one of Thailand's most important watersheds within two National Forest Reserves in the Nan River basin. Most farmers have no legal land tenure. The project population is about 20,000 scattered in 45 villages encompassing lowland Northern Thai and Thai Lue, and ethnic minority groups including Khamu, Hmong and Mien peoples.

The immediate project objectives include strengthening local organisations for natural resources management (NRM), reducing the area of shifting cultivation, controlling forest fires, inducing more sustainable agricultural land use, and increasing forest cover. In other words, the project aims to showcase how local communities can sustain life within National Forest Reserves and at the same time collaborate with government agencies to improve their management. This approach is in line with recent legislative and policy changes introduced by the Tambon (Sub-district) Administration Act of 1994 and the 1997 Constitution, which devolved the powers in managing natural resources from the central to local levels.

THE USE OF 3-D MODELS IN THE PROJECT CONTEXT

The project implementation approach included the use of 3-D models in all 45 project villages as a means for facilitating learning, negotiation and information exchange with respect to existing land use including farmland, community forest and conservation areas and forest fire control practices.

Some villages had already manufactured 3-D relief models in the context of the RFD-funded Accelerated Highland Forest Regeneration Project (1993-1996). During its first year, the UNWMP had completed 23 additional village models covering areas of 20 to 100 km^2. Villagers, assisted by Community Coordinators, had located agricultural fields and forest areas on the 3-D models. The data were later transferred to a Geographic Information System (GIS) set up by the project.

During its second year, the project realised the need for larger Village Watershed Network (VWN) models to better deal with all issues transcending single village boundaries and to meet the needs of the newly established VWN. Seven VWN models encompassing areas ranging from 150 to 350 km^2 were completed, together with one district model and one project model covering 300 and 1007 km^2 respectively (see **Table 1**).

During the first four years of project implementation the models were used for land use planning and boundary negotiation in conjunction with the establishment of a village-based micro-credit facility, training activities and the launching of pilot projects aimed at improving the management of natural resources.

In 1997, the project adopted a 1:12,500-scale in manufacturing the new village models because of existing aerial photography taken in 1996 at a scale of approximately 1:13,000 covering the entire project area. The aerial photos together with

Table 1. 3-D Models in the Upper Nan Watershed (1993-1999)

Type of Model	Qty	Main uses (project perspective)
Village 3-D Model (1:12,500, 1:10,000 and 1:6,500)	22	**1993 to 1996:** Models manufactured in the context of the RDF-funded Accelerated Highland Forest Regeneration Project (1993-1996), displaying actual land use and cover.
Village 3-D Model for villages covering areas of approximately 20-100 km^2 (Scale 1:12,500)Unit cost: USD 69	23	**1998 and 1999:** Display of existing agricultural land use (paddy fields, orchards, upland fields, forest fallow), community forest and conservation areas. **2001 updates**: Display of changes in land use due to paddy land development, tree crop planting using village revolving funds and fit with RFD watershed land use recommendations.
Village Watershed Network (VWN) Models covering areas of 150 to 350 km^2 (Horizontal scale 1: 20,000, vertical scale 1:10,000)Unit cost: USD 299	7	**1998 and 1999:** Used for conflict resolution in land disputes over fire damages and harvest of non-timber forest products. Successful for (i) defining village boundaries for Natural Resource Management including community-based fire management and (ii) strengthening VWN rules and regulations for NRM.
Project area 3-D Model Land area: 2,100 km^2 including project area of 1007 km^2 (Scale 1: 50,000, 100-m contours) Unit cost: USD 413	1	**1997:** Used at the Project Office for briefing visitors. Replaced by multimedia and GIS generated displays.
District 3-D model Land area: 400 km^2(Scale 1:25,000)Unit cost: USD 681	1	**1998:** The model includes 50% of the project area, 4 Village Watershed Networks and 22 villages. The District Officer uses it for briefing small groups of visitors. Potential use for water resource management and for identifying villages at risk from flooding and mudslides and for promoting awareness on water resource management.

Notes: The cost refers to the materials used for manufacturing the different types of models. Participants collaborated on a voluntary capacity without receiving any monetary compensation. Exchange rate $1 = 44 Thai Baht (January, 2002).

available LandSat images were analysed to establish a reference baseline for a pre-project land use scenario. Some of the models made before 1996 were done at 1:6,250 and 1:10,000 scales.

Fifteen Community Coordinators (CCORD) working in the 45 villagers were trained in the preparation of 3-D models. Five of the CCORD who were already experienced in the practice because of their previous involvement in the DSM-HDP, provided technical assistance to the Village volunteers in preparing the models. The data depicted on the models reflected the farmers' knowledge validated through field surveys. Illustrated data included village location, watercourses, roads, agricultural land (paddy fields, orchards, slash and burn farms, upland agricultural fields, and forest fallow), and forest areas. The latter incorporated forest conservation areas at the head of mini-watersheds, RFD reforestation and natural regeneration areas covering about 10% of the project area; and other forest areas used by the communities. The location of households, agricultural fields and forest areas was also recorded on a 1:12,500 map for entry in the project's GIS database. However, the facilitators did not fully adopt the process of transferring community knowledge (mental maps) to the models by using pins and colour-coded yarns as described by similar experiences in the Philippines (Rambaldi *et al.* 2000).

RELIEF MODELS IN PRACTICE

Experience gained during the project period highlights that the geographical coverage of models and their scale strongly influence their outreach and define their uses. The different types of models in use within the project are listed in **Table 1**.

Village 3-D Models

The 1:12,500-scale models usually include at least one mini-watershed covering areas of 20 to 100 km^2. These models have been useful in displaying the agricultural and forest areas surrounding villages. In 1998 and 1999, some models were used for defining village boundaries affecting local access to resources through an intra-village negotiation process (**Figure 1**). Villagers also used the models to learn how to read maps, interpret spatial information, deal with village-based conflicts and brief visitors.

Photo courtesy of UNWM Project

Figure 1. Village Model and RFD Watershed Model being used to establish NMR boundaries

All village models were updated in year 2001 as part of the participatory NRM planning process that led to the preparation of the year 2002 annual work plan. The exercise also served to involve villagers and government officials to add transparency to ongoing activities in assessing the compliance of the current land use with the RFD watershed classification.

Village Watershed Network 3-D Models

The need for larger models encompassing a number of villages emerged in 1998 as a necessity for addressing intra-village conflicts and improving natural resource management including fire. This has led to the manufacture of seven models covering up to 350 km^2 , including 6 to 8 villages.

Village volunteers prepared these models with the support of community coordinators. Some models cut across sub-district and district administrative boundaries and were used for negotiating the VWN and inter-village boundaries for NRM. This type of model (**Figure 2**) proved to be extremely useful for a number of purposes including boundary negotiations, definition and rights for harvesting Non-Timber Forest Prod-

Photo courtesy of UNWM Project

Figure 2. VWN model being used for negotiating household-specific fire management responsibilities

ucts (NTFP) and allocation of fire management responsibilities.

VWN Models for Addressing Land Disputes

The use of the VWN models has been instrumental in defining village boundaries and in solving territorial disputes between neighbouring villages (**see Box 1**) or conflict over use of and access to resources including grazing land, irrigation water, NTFP and others. These models were particularly useful in dealing with one issue – fire, which has deep environmental, social and economic implications in the area.

The use of VWN Models for Improved Fire Management

In 1998, over 23% of the project area was burnt. Fire spread from one village to other villages, damaging houses and orchards. A conflict mitigation process followed the event and involved the use of relief models. The outcome has been successful: all villages agreed on a joint forest fire management programme involving both the community and the RFD. The agreement covers the entire 1,007-km^2-project area.

The agreement among parties included the spatial definition of responsibilities including the location of firebreaks. Single villages assumed direct responsibility for fire prevention and fire suppression. Rules and regulations were set and agreed upon by all villages within each of the seven networks.

Some Networks used Village 3-D models to delegate responsibilities for community-based fire management to households farming in micro-watersheds. The respective household would address any fire starting within a particular micro-watershed regardless of who ignited it.

After this initial planning process, the fire management plan has been revised annually on the basis of changing agro-ecological conditions and land use. The plan includes the establishment of firebreaks to protect existing RFD and community forest areas and to reduce the risk of fires from spreading inside the project area.

Box 1

Case 1: Illegal sales of land without any legal title done by Northern Thai to Hmong farmers to plant fruit trees within critical watershed areas located within a National Forest Reserve.
The sub-district administration used the 3-D model and handheld Global Positioning System (GPS) devices to determine the location of the fields to acquire better control on the eventual expansion of the area planted to fruit.

Case 2: Where one village tried to take advantage of a Government Cabinet Resolution of 1997 to record shifting cultivation areas in National Forest Reserve at the District Office. They included the community forest conservation area of a neighbouring village as being part of their shifting agricultural area. No field surveys were done to verify the claim before this would be submitted to the district office.
The use of the VWN model with the agreed boundaries for NRM helped solve the dispute.

The Project 3-D Model

In 1998, the project manufactured a small-scale (1:50,000) 3-D model covering the entire project area to be used for communication purposes. The information displayed on the model reflected the RFD watershed classification through the use of colours. The model had limited use for planning purposes because of its small scale and inherent limited capacity for accommodating village NRM boundaries and details on land use. As of now, the Project Management prefers using audiovisuals for briefing visitors.

The District Model

The 1:25,000-scale district model portrays an area of about 400 km^2 and is mainly used for briefing visitors by the District Officer. However, it could be important for identifying villages exposed to the risks of flash floods and mudslides. Heavy rains and associated mudslides resulted in a remarkable loss of lives in two villages in northern Thailand in 2001; 37 people perished in Ban Hong in Phrae province in May, and 130 in Ban Nam Kor in Petchaboon province in August. In both cases, heavy downpours resulted in deadly nighttime flash floods because there were no upstream water discharge monitoring facilities to provide any sort of early warning system.

The planned government strategy to address the problem includes the provision of more accurate forecasts by using computerized systems to predict climatic phenomena over 5 km^2 cells, the installation of additional rainfall gauges and the identification of villages at risk by the use of 3-D models and vegetation cover assessments.

ADDING TRANSPARENCY BY THE USE OF GIS

Watershed Classifications

The entire catchment of Thailand's most important river, the Chao Phraya, lies within the national boundaries. The Nan River is its largest tributary. The project area in the upper Nan watershed is one of the key watersheds in the country, as its catchment provides over 50% of the water to the Central Plains. The last century witnessed a sharp increase in shifting cultivation within critical watersheds in northern Thailand by both hilltribe and Northern Thai farmers. In 1978, the RFD zoned the upland areas using slope as the main criterion, as shown in **Table 2**.

As decided, the RFD watershed classification in all the village 3-D models shall be added when updating the village 3-D models in year 2000. This additional set of information would assess compliance between existing community land uses and the RFD guidelines for critical watersheds after 3 years of project implementation.

The analysis has been done within the current legal forestry framework. The analysis assumed that the potential of community-RFD conflicts would be lessened if the existing land use would be consistent with the watershed classification guidelines, and

Table 2. Royal Forest Department Land Classification for Watershed Areas

Description	Slope	Recommended Land Use	Colour Used on 3-D Models
Class 1 A and 1B	>60%	Watershed conservation forest and regenerating secondary forest	Dark and light green
Class 2	35% to 60%	Forest cover or mining	Brown
Class 3	25% to 35%	Forest, agricultural tree crops and mining	Yellow
Class 4	6% to 25%	Agricultural field crops with soil conservation and other uses	Light blue
Class 5	Less than 6%	Agricultural paddy land and other uses	Pink

that the sustainability of the system would be enhanced if local communities could prove to be active actors in managing fire.

Actual Agricultural Land Use and Community Forest Conservation Areas

The agreement reached by all stakeholders on defining common village boundaries and the success of the associated community fire management programme have been perceived as an important achievement at all levels. This learning induced some of the RFD Watershed Management Chiefs (government officials) to call for the conduct of a survey of the agricultural lands located within the two national forest reserves with the objective of containing any further conversion of forest into farmland and concurrently supporting the regeneration of natural forest.

Farmers operating on steep slopes falling into watershed classes 1A, 1 B, or 2 would be encouraged to allow these fields to revert to forest fallow. In return, they would be provided access to micro-credit to be used for establishing paddy fields, tree crops, small livestock and off-farm enterprises for villages located both inside and outside National Forest Reserves.

In 45 villages, the farmers and CCORDs located farm plots and community forest conservation areas by fixing the coordinates of the centre of the plots with the use of the GPS. Farmers provided estimates of the areas of their fields. Household-level disaggregated data were entered into the GIS database and crossed with the RFD land use classification (**Figure 3**).

Farms are generally found within the agreed NRM village boundary with the exception of villages – located along the national border – which were relocated in the 1970s due to security problems. In these cases many farms are located several kilometres away from the settlement and within the boundaries of neighbouring villages.

The project faced a new situation with the alternative of making a larger village model or liaising with the neighbouring villages to locate the fields on their models. The second option prevailed, and was combined with the use of the larger (but smaller-scale) VWN relief models.

MANAGING CONFLICTS

The first step in preparing the year 2002 work plan involved the updating of the village 3-D models to include data relevant to the main project stakeholders and partners – the farmers, the Royal Forest Department, and DANCED. The assumption (to be verified in the course of action) is that conflicts between farmers and RFD may be predicted, spatially confined and better managed by being fully aware of their nature and location (re: location of farmers' fields vis-à-vis the RFD watershed classifications). The micro-credit facility, which is made available through village revolving funds, would help solve existing conflicts and induce the development of more sustainable farming and agroforestry practices.

IMPACT ON FIRE MANAGEMENT

The involvement of different stakeholders in the planning process and the use of mapping tools for visualizing issues has been instrumental in raising the level of community participation in project implementation. In effect, the government and com-

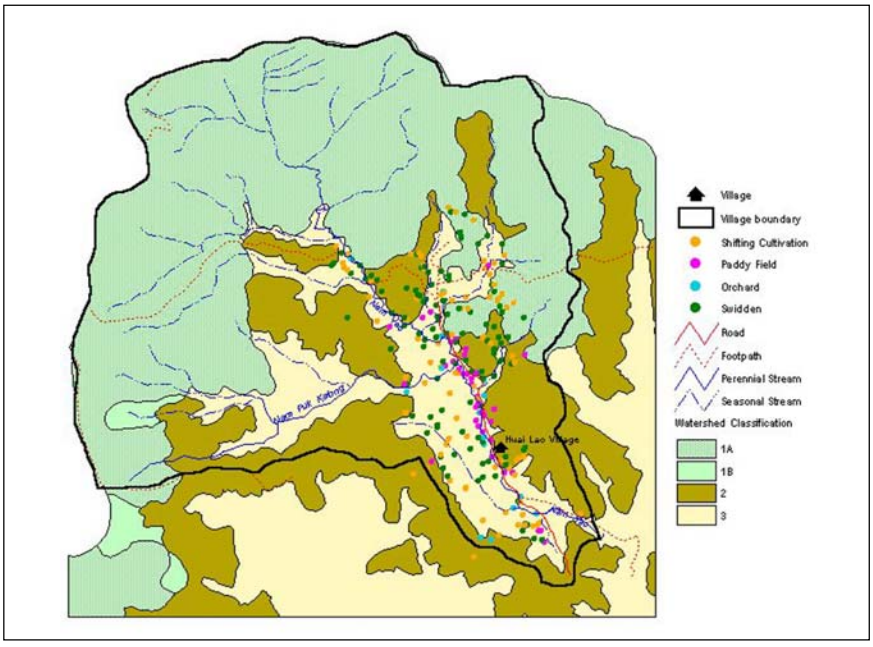


Figure 3. GIS generated village map showing the 4 RDF watershed classifications and the location of farms.

munity partnership on managing fire has resulted in a substantial decrease in forest fires within the project area. The area burnt dropped from 24% in 1998 to less than 2% in each of the succeeding 4 years, from 1999 to 2002. So far, the project has shown how communities in the forest can continue their livelihood while helping rehabilitate their environment.

LESSONS LEARNED

In 1996, when the Upper Nan Watershed Management Project was launched, plans were made to use 3-D models coupled with GIS in all 45 villages. Computer equipment and plotter were purchased and technicians employed to set up a full-fledged Geographic Information System. These activities were designed without any clear rationale on how these tools would be used to facilitate improved natural resource management. The 1999 mid-term review mission recommended a change in direction from watershed management to the preparation of village NRM plans. The scope of action of these tools was reassessed in year 2000 and corrective actions were taken to effectively integrate these in project participatory planning and monitoring systems.

The village 3-D relief models were found to be most useful for those villages located in hilly areas inside the National Forest Reserves. For the other villages located on the edge of the National Forest Reserves, and on flatter land, the village 3-D relief models were less useful since cadastral surveys had been completed and lands have been titled in some of the areas.

However, the VWN models covering larger areas and several villages proved to be essential tools for community based planning and action. This type of model has been instrumental in negotiating village boundaries, reducing conflict over natural resource and improving watershed management. In addition the models have eased communication and facilitated interaction between villagers and government officials and paved the way for collaborative efforts in managing forest fires.

Considerable resources are invested in making 3-D models and linking these with GIS facilities. Careful planning and regular on-the-job training of Village Leaders and Community Coordinators is needed in order to fully utilise their value as participatory land use-planning tools. Land use is changing and unless regularly updated, 3-D models would simply become snapshots in land-use history.

The 3-D models are excellent devices for negotiating boundaries for improved NRM. Experience has shown that in defining the geographical coverage of a model, facilitators should have an approximate idea of where boundaries could be. This preliminary assessment, to be done jointly with the local communities, would avoid the mistake of making small models incapable of accommodating prospective boundaries, thus of using these for desired purposes.

Ideally, at the very start of the project, the models should have depicted actual land use - as perceived by the people – with the use of colour-paint, and official watershed classifications as superimposed colour-coded lines (i.e. yarns). By doing this, the models could have highlighted possible areas of conflict between actual and recommended land use at an early stage of the project.■

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Acknowledgements

Acknowledgements are made to the Royal Forest Department and the Danish Cooperation for Environment and Development (DANCED) from 1996-2001 for the opportunity given to us to implement this challenging project and for recognising the importance of 3-D models for participatory land use planning. Since January 2002, the project development assistance funding has been provided through Danish International Development Assistance (DANIDA). Technical assistance has been provided through the Danish consulting company, RAMBOLL. The GIS technicians and project Community Coordinators are to be complimented for the quality of the delivered on-the-job training and for assisting communities in updating the village land use maps. Village volunteers need a special mention for their efforts in manufacturing models and their openness and precision in depicting their knowledge on them.

References

Jantakad P., and P. Carson, 1998. Community-based Natural Resource Management from Villages to an Inter-Village Network. *In:* Proceedings of the workshop on "Community based Natural Resource Management Experiences in Upland and Highland Areas," Chiang Mai, June, 1998. Thai-German Highland Development Project. Chiang Mai.

Limchoowong, Samer. 1995. Watershed Management by Local Communities. Paper presented at a training course at the Regional Community Forestry Training Center (RECOFTC), Bangkok. June 1995.

Rambaldi, G. and J. Callosa-Tarr, 2000. Manual on Participatory 3-Dimensional Modeling for Natural Resources Management, Protected Areas and Wildlife Bureau-Department of Environment and Natural Resources, European Commission, Quezon City, Philippines.

UNWMP. 1998. Village Rules and Regulations for 45 Project Villages (Thai and English). Royal Forest Department. Khao Noi, Nan, Thailand.

UNWMP. 1999. Village Watershed Network (VWN) Rules and Regulations for 7 VWN, (Thai and English). Royal Forest Department. Khao Noi, Nan, Thailand.

UNWMP. 2001. GIS Maps Showing Existing Agricultural Land Use and Royal Forest Department Watershed Classification Data for 45 Project Villages. Watershed Management Office, Royal Forest Department. Nan, Thailand.