The Resource User's Knowledge, the Neglected Input in Land Resource Management

The Case of the Kankanaey Farmers in Benguet, Philippines

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1. INTRODUCTION

Sustainable land management means the utilisation of the land and its resources to meet the present needs while maintaining its productive capacity for future use. In the past, often, resource users were not considered important actors in the sustainable management of resources. Their practical activities were usually seen as contributory factors to the degradation of the resources. As a consequence, measures designed to sustainably manage the resources only address the issue discerned by scientists. Previous experiences, however, have shown that without the participation of the resource users, it is more likely that any effort to conserve and manage the resources in a sustainable way would fail. As such, recently attention has been directed towards the crucial role resource users can play in the management of the resources. This recognition is a result of the failures of many development-related programmes that were conceived to alleviate the continuous and alarming impacts of resource degradation.

The question is how to involve the resource users, that is to say the farmers, in the proposed sustainable management activities. One way is to start understanding their unique knowledge or ways of using and managing their resources, e.g. land. This may include comprehending their perception, actions or behaviour towards land. Why farmers are behaving the way they do? However, to understand these aspects of the land users requires information from them. Normally, resource management planners or decision-makers have no access to this type of information simply because it is not available. Making resource user's-based information available requires not only documenting, recording, storing and analyzing their acquired knowledge, but also understanding of how such knowledge has evolved or developed. In this way, we may be able to understand the why, the how and the what in the resource user's behaviour of using and managing their land.

The study explores the concept of farmers' knowledge, to understand it better and to analyse it using modern information systems. Primarily, it addresses three major questions:

Why study farmers' knowledge?;
- How can farmers' knowledge be studied and extracted; and
- What can modern information technology offer to make farmers' knowledge useful, available and accessible for planning and decision-making in land resource management?

The study has a rather straightforward answer to the first question. Such knowledge is an important input in land resource management particularly in developing countries where a large percentage of land users are farmers (Richards, 1979; The Brundtland Commission Report, Our Common Future, 1987; The Earth Summit in Rio de Janeiro, 1992; Warren, 1992; Davis and Ebbe, 1993; Biot et al., 1994; Murdock and Clark, 1994; FAO/UNEP, 1995). Consequently, this brings us to the second question, leading the study to adopt the ethno-ecological approach (Section 1.1) and to construct a model of farmers' knowledge development (Section 1.2) to reach the aim of a better comprehension of such knowledge. Likewise, the third question resulted in the use of a geographic information systems (GIS) combined with conventional statistical tools to explore the possibilities of formalising farmers' knowledge while also testing the model empirically.

The expected outputs of the study are the framework and various methods designed to comprehend better farmers' knowledge and to make it accessible for planning and decision making in land resource management. Part of the assumption was that the outcome of the study could be used to generate interest among farmers by showing how they cognized the situation in the area as simulated in the computer.

1.1 The Approach

The adoption of an ethno-ecological approach in the study meant that farmers' knowledge was studied in the context of man-environment interactions based on the point of view of the farmers, in combination with our interpretation of their views. According to Hardesty (1977) and Fowler (1977), ethno-ecology was first considered as an approach in human ecology. Its application was said to have been pioneered by Harold Conklin (1954, 1967) when he studied the shifting cultivation of the Hanunoo tribe in Mindoro Island in the Philippines. It has also been noted that previously, the focus of the approach was only the categorization by indigenous people of the environment, e.g. a mere listing of categories of plants (Martin, 1995). However, as some people recognized the importance of ethno-ecology as a discipline, it started to have a broader scope (Martin, 1995; Patton, 1993; Toledo, 1992).

Toledo (1992), in an attempt to establish the approach as a new field of scientific knowledge, stressed that its aim should be the evaluation of the knowledge (intellectual) used and of the practical activities executed by a certain human group during the appropriation of their resources. In this perspective, the tasks of the ethno-ecologist are: (a) the exploration how the rural producer codifies and utilizes his productive space and

(b) the confrontation of such codification and utilization of the productive space with the observer's analysis (see Toledo, 1992; Patton, 1993 for further details).

1.2 The Model of Farmers' Knowledge Development

In this study, it was necessary to have an understanding of how knowledge of the farmers is acquired or developed. Thus, in agreement with ethno-ecological approach, a model of farmers' knowledge development was proposed. As knowledge is studied in the framework of man-environment relationships, however, it is essential to simplify the concept "environment. "In the study of man's perception of his environment, the issue of simplifying the environment has been raised. In resolving the issue, Sonnenfeld (1972) grouped the environment into four aspects: *geographical*, *operational*, *perceptual* and *behavioural*. The geographical environment relates to the total universe external to man, far or near, whether it impinges (influences) on him directly or indirectly or not at all. It is the universal environment of man. Operational environment is man's immediate surroundings, quite literally, it is the environment in which he operates. The perceptual environment includes only those elements in the operational environment of which man is aware of, whereas the behavioural environment requires not only awareness of a particular facet of the environment but a behavioural response as well. This last type of environment appears to be the appropriate concept for the study, that is to say studying the farmers' environment in which they operate and are aware; and studying their behavioural response as well.

Figure 1 shows the proposed model of farmers' knowledge development. In the study of knowledge, man is obviously an important element, as he is the possessor of knowledge. Farmers' knowledge is considered here as the cognitive view towards their total milieu or environment, whereas their responses or behaviour are reflections of such knowledge or the practical activities of the farmers.

The farmers' environment does consist of complex factors such as the physical, biological, economic and socio-cultural conditions prevailing in their farming areas. Specifically, in their natural (physical and biological) environment, we studied the farmers' subdivision of the landscape into microregions, their concept of altitude, temperature, soil, soil fertility depletion, soil erosion, slope steepness, season, typhoon, water supply, flooding and others. Likewise, socio-economic factors include farmers' perceptions of market price for their harvest, farm operating capital, particularly the cash element, prices of farm inputs, extension services and others.

With respect to farmers' response or behaviour, it is interpreted in the study as the actions taken by them in response to their view of their environment. These actions include those strategies and practices they employed on their farms.

How do these concepts, shown in Figure 1, relate to one another? Man as a human being may either relates/reacts or interacts himself with the environment. In the model, the primary assumption is that a farmer is a thinking individual whose interactions with the environment are mediated by mental processes and a cognitive representation of that environment. These mental processes are represented in the model as cognitive processes, which include sensing, perceiving, remembering, imagining, judging or deciding. According to de Groot's (1969) idea of cognition, this includes observation, supposition, expectation, testing and evaluation. This means that a farmer is involved in obtaining, storing, using and operating upon information during a cognition process. Furthermore, these processes are assumed to result in the formation of his mental image or cognitive view for this matter of a particular component of the environment, e.g. soil. As such, he should be able to understand the principles and the processes that work within the specific condition or environment.

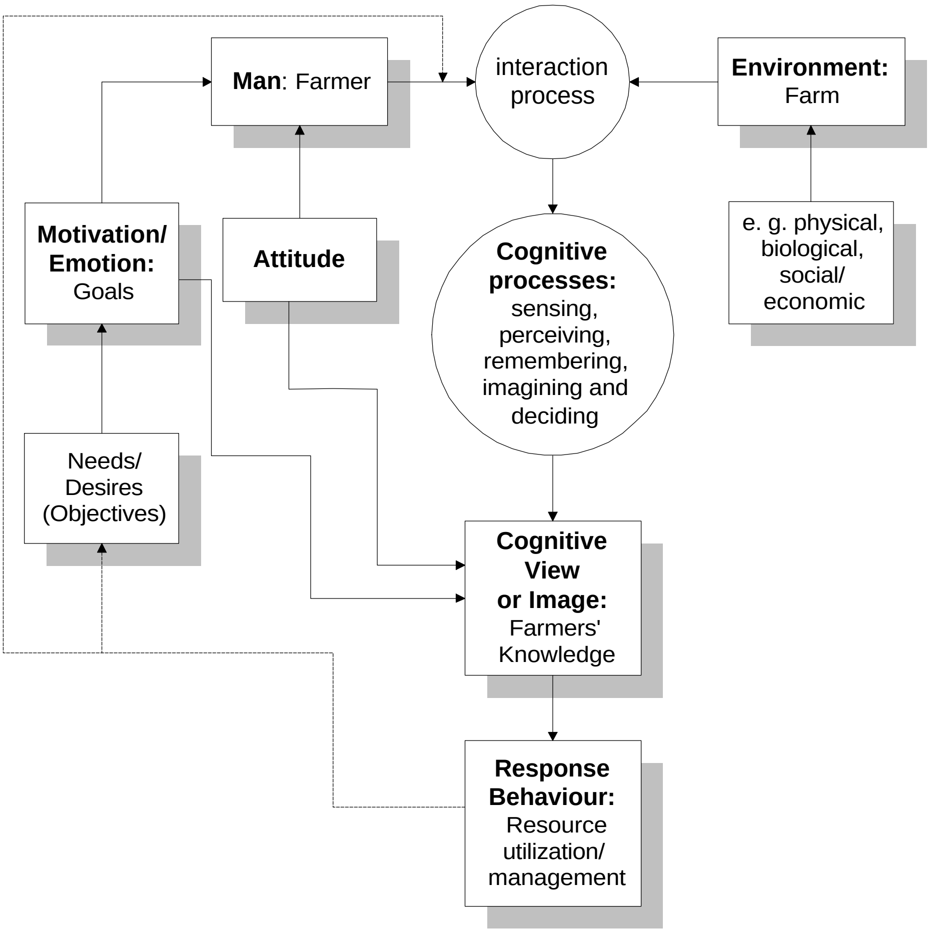

Figure 1. A model of farmers' knowledge development.

The farmer also has particular needs or wants in life. An example of a farmers' need is the need to survive. These needs motivate farmers to seek to achieve particular goals. The goal can be a good harvest in order to raise profit. Hence, such motivation also influences his views and reactions/responses toward the environment. As reflected in Figure 1, the cognitive view and response behaviour of the farmers are assumed to be induced by motivation or emotion and attitude. Responses or behaviour of the farmers depend, among other things, on their cognitive view of the environment. This means that their behaviour is a consequence or a reflection of their view of the environment.

Another assumption in the model is that farmers' response behaviour can change as his cognitive view changes, while continuously interacting or relating with the environment. This dynamic nature can be attributed to the continuing acquisition of new information or a changing environment and goals, or other factors. The change could be a refinement or modification, or a complete change of previous response behaviour. In this respect, there is a cyclical process involved in farmers' knowledge development. In the model, this is shown by a broken line from variable response behaviour to the line from man to the interaction process.

1.3 Objectives of the Study

The study pursued two objectives as follows:

- To contribute to existing knowledge on how land can be managed appropriately through better understanding of farmers' knowledge and
- To find out how modern information technology can be used in analysing and transforming farmers' knowledge into something relevant and accessible for planning and decision-making in the sustainable management of the land.

To achieve these objectives, a number of cases were considered. These include:

- The qualitative and quantitative analysis of the land use history in the area in support of a better understanding of farmers' knowledge;
- To identify and analyse farmers' cognitive views of specific elements of their environment;
- To test how spatial and non-spatial knowledge of the farmers can be stored, manipulated and analysed in a GIS environment; and to determine the spatial relationships between farmers' environmental knowledge and field activities;
- To quantify and model farmers' understanding of soil degradation;
- To examine and analyse farmers' spatial crop decision behaviour; and
- To integrate as a test the results related to farmers' and scientific knowledge; and to carry out matching and comparing different information types particularly farmers-based information with scientific-based information.

On the basis of the three major questions and objectives of the study, two general hypotheses were set: (a) the farmers possess cognitive views of their environment which are reflected in their response behaviour or resource utilisation activities and (b) modern information technology and other scientific methods can be utilised in formalising farmers' knowledge. Specific hypotheses based on these general hypotheses were also formulated and are shown in relevant cases considered in the study.

1.4 General Methods

This section describes the research setting, type and source of data, the farmers as informants and their selection, the techniques and instrument used for retrieving farmers' knowledge, the statistical tools applied and the type of GIS software used. The specific methods are treated in relevant cases that this study has focused on.

This study was undertaken in Buguias municipality located in the northern part of Benguet province, which is one of the provinces in Northern Luzon, Philippines. Its topography is generally characterised by rugged terrain. The elevation ranges from approximately 1200 to 3000 m asl, while the climate is temperate, with an average temperature of 22ºC. Its average annual rainfall is about 3200 mm, based on 1987 and 1988 rainfall observation by the Community Environment and Natural Resource office of the Department of Environment and Natural Resources (Barangay Development Plan for Abatan, Buguias: 1993-2000). Economically, the municipality depends on agriculture, particularly horticulture.

The research used both primary and secondary data. Primary data are those that were retrieved from the Kankanaey farmers and scientific practitioners within and outside the study area. The farmers have their own dialect known as "Kankanaey," which distinguishes them from other groups in Benguet province. The secondary data consisted of different analogue maps, aerial photographs, land satellite data and published and unpublished documents. The Kankanaey farmers are those who are native or grew up in the study area; and area engaged in growing vegetables and other crops. In this study, they were considered as the resource users (land users), thus they were the major source of primary data.

The Kankanaey farmers were treated in the study as informants and not merely as respondents, which means that we let them feel that we were just colleagues. We showed appreciation on what they have and how they are doing things which often made them feel proud of themselves. This also allowed us to learn a lot from them. In addition, we showed to the farmers that they are more knowledgeable about their community and their activities than we are. Respecting and adapting to their way of life is another factor which contributed to the friendlier atmosphere during the interview.

The farmers were identified geographically. The use of a geographic information system (GIS) in the research determined this approach. The land management units (LMUs) of the Bureau of Soil and Water Management (BSWM) of the Department of Agriculture (Manila) for the study area were used in this respect. There are about eight LMUs present, but two (LMUs 7 and 8) were combined making the total number of LMUs seven. A total of 131 fields were visited, each more than once. They were randomly selected within the seven LMUs and the farmer-owners were interviewed. The farmers may have one or more fields. In cases where they have fields in different LMUs, they were asked about the conditions of their fields in both locations.

To retrieve farmers' knowledge, a number of techniques were adopted. These include rapid rural appraisal (RRA); village immersion; the farmer-based interview schedule; participatory techniques, e.g. confrontation naming of soil and the use of aerial photographs for delineating boundaries of their indigenous landscape microregions; field visits and observation. Prior to the adoption of these techniques, contacts were made at the national, provincial and local levels.

A checklist was used to collect data from the farmers. It contained issues related to the major subject matter of the study. In this case, quite often, we collected data by conversation. Mostly we asked an open question, which allowed the farmers to think and talk freely about the subject matter.

The statistical tools used in the study were multiple stepwise regression analysis and multivariate analysis, in particular principal component analysis. Pearson's correlation coefficient and Spearman's Rho coefficient were also used. For simple analysis, frequency counts, percentages, means and rankings were employed.

The study also used a geographic information system (GIS) as a tool for the storage, spatial analysis, manipulation and integration of data collected from the farmers and scientific sources. The capabilities of a GIS software "Integrated Land and Water Information Systems (ILWIS)," were exploited in the study. The specific procedures employed are given where each application is discussed.

2. Resource User's Knowledge in Land Resource Management

The resource user's knowledge cases in land resource management considered in this study are discussed below.

2.1 Land Use History in Support of a Better Understanding Farmers' Knowledge

To understand better farmers' knowledge and actions, we analysed the history of the land use systems in the study area. In addition, the dynamic aspect of such knowledge was gleaned from the study of the land use history. Specifically, we analysed the pre-war, post-war and present land use systems. This includes the detection of land use changes and the extent of deforestation from 1949 to 1993. Qualitative analysis was done both for the pre-war and post-war periods, whereas quantitative analysis was carried out for the latter period.

Methods

The data used in this case were gathered from various sources. The primary data were mainly taken from repeated informal open interviews with the farmers, particularly the old ones. For the secondary data, we depended on published and unpublished documents, aerial photographs (APs), analogue maps and land satellite images. These last three sources were primarily used to estimate the land use changes that had taken place in the area from 1949 to 1993. Sets of algorithms were required to generate the data need from the aerial photographs and satellite images.

The sequence of activities involved in the processing of APs were interpretation, digitizing, monoplotting and connecting open segments (see Lawas, 1997 for details). Two sets of aerial photographs with the scales of 1:50,000 and 1:60,000 were interpreted to extract information about the land use systems in 1949 and 1980, respectively. Five land use classes were identified: dense forest, open forest, agricultural areas, built-up and grassland/bushland areas. These classes could be easily distinguished from the aerial APs using a table stereoscope. In digitizing the boundaries of each land use class, we identified the ground coordinates of the study area. The digitized segments were geometrically corrected for relief displacement applying the *monoplotting* program available in ILWIS GIS. In this case, a digital terrain model (DTM) was created and used.

For 1993 land use, Landsat TM was used. Preprocessing of the image which included haze and geometric correction was performed. Affine transformation was also accomplished. Thereafter, spectral classification using supervised method was undertaken. For this purpose, reflectance values in the image were classified according to the above land use classes, with the addition of a *shadow* class. Bands 1, 3 and 4 were utilised for the selection of training samples to represent each class. A colour composite map was generated. After the identification of samples was completed, the maximum likelihood method of classification was employed. The classified image was further assessed according to its accuracy in relation to real world conditions. This step showed how acceptable or how far the classification result is true to real conditions.

Summary of Results and Conclusions

The qualitative analysis of the pre-war land use systems in the study area showed that the inhabitants used to cultivate paddy rice along the Agno river (major river) and creeks. In the upland areas, sweet potato was grown. Livestock raising, particularly cattle and hogs, were also a main source of livelihood for the people. In the late pre-war period, the inhabitants started to shift to vegetables, but this was interrupted by the war. As a whole, pre-war land use systems in the area can be characterized as subsistence agriculture that was concentrated mainly along the rivers and creeks. This suggests that the area was still dominantly covered with forest.

During the early post-war period, vegetable cultivation continued to expand. As the inhabitants realized that the area was suitable for vegetables, they began to abandon shifting cultivation. Others began to clear forest areas for vegetable plots and people migrated to areas which were considered suitable. Bulldozers were used to flatten hilltops to open new gardens in the cloud-forest highlands. Commercial logging was also common and people were also dependant on forest for fuelwood. This marked the gradual transformation of a forest landscape to an agriculture landscape. This situation became even more serious from the early 1970s. Vegetable terraces now dominate the area and only patches of forests can be observed. As a consequence, environmental degradation has accelerated and has even become severe. Erosion, flooding, diminishing supply of water during dry season, etc. are now common.

The loss of forest to agriculture and other land uses – as qualitatively analysed above – has also been confirmed quantitatively using GIS in which data from aerial photographs and remote sensing (Landsat TM 1993) were utilised. The trend of the transformation of the landscape from one use to another has been determined from 1949-1993. The result confirmed the qualitative analysis that forests were very pronounced in 1949. By 1980, a lot of forest had disappeared, and by 1993 only patches of them could be observed (see Figure 2). GIS has also enabled us to locate where deforestation has started first and which land use type has been converted first to agriculture. Between 1949 and 1980, which covers 31 years, the annual rate of deforestation was a little more than one percent. This was almost doubled (about two percent) in the period 1980-1993, which involved thirteen years. In the findings, the open grasslands/shrub-lands appear to be more vulnerable to agricultural expansion than forest. It is easier and less expensive to convert grasslands/shrub-lands than forest areas.

The transformation of the landscape of the area is the work of humans: the inhabitants have shaped it. The elites (rich farmers) have played a major role in this transformation. With their financial means and commercial motives, they have contributed to the acceleration of the existing problems in the area. Impoverished people, on the other hand, continue to move to marginal land because they have no other alternatives.

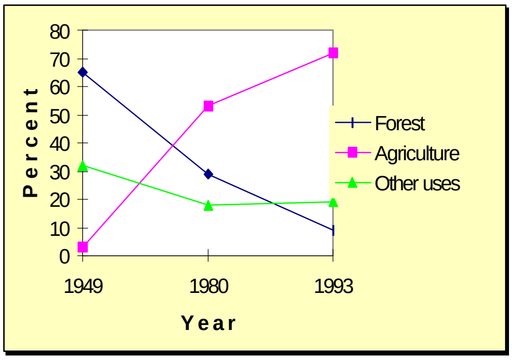

Figure 2

Land use changes from 1949-1993.

In other words, both the wealthy and the poor have contributed to the present environment of the area. One must also remember the influence of colonizers, e.g. Spaniards and Americans, who started to denude the area under forest.

The present land use system will probably continue to be purely market-oriented as it appears to us that the inhabitants will certainly not return to their old land use system, i.e. rice and sweet potato-based farming system.

Finally, the change in land use systems appears to demonstrate the dynamic aspects of the Kankanaey farmers' knowledge, for example, the shift from swidden or subsistence farming to commercial vegetable growing.

2.2 Farmers' Cognitive Views of their Environment

Cognition is a mental process by which people acquire, organize and use knowledge (Gold, 1980). It is the basis of human actions or activities they perform in everyday life. In this study, cognition refers to the perceptions or views and knowledge of the Kankanaey farmers about their environment. This cognition is reflected in the way they respond to a specific component of their surroundings. Responses are considered to be how they utilise and manage their resources, the land in particular. Such responses may not necessarily be rational. For instance, individual actions which lead to desertification can be characterized as a lack of perception of the broadest scale of the consequences of such actions (Lambin, 1993).

This section examines the Kankanaey farmers' cognition of their environment and their adaptation behaviour. The basic question is how farmers view and interpret their environment and how they react to it. The hypothesis in this case is that: Kankanaey farmers possess knowledge of their environment which is reflected in their cognition of a particular phenomenon and that they are able to relate such knowledge to their behaviour in farming. The specific issues considered were the farmers' perception of their major farming problems and their cognition of the natural environment.

Methods

This particular case is the qualitative part of the study. A descriptive analysis was adopted for the data collected. The different techniques used for retrieving such data from the farmers are indicated above (Section 1.4: General Methods). It should be noted that during the collection of data, we often asked open questions that allowed them to discuss and converse freely.

Summary of Results and Conclusions

As indicated above, there were two issues that had been addressed in this case. Firstly, the farmers' perceived major farming problems and secondly, their cognition of some components of their natural environment, e.g. concepts of land, landscape subdivision into microregions, soil, slope, altitude and temperature, water, season, typhoon, flooding and waterlogging, crop pests and diseases and others.

The farmers enumerated several <u>problems</u> which they encountered during the execution of their farming activities. The three leading ones include:

- soil fertility depletion;
- lack of capital, including credit; and
- unstable or fluctuating prices of their produce.

These problems were mentioned by 97, 77 and 68, respectively of the farmers interviewed. The farmers' reasons and perception of these problems, e.g. how each problem influence one another and their effects on the farmers' activities are discussed in Lawas (1997).

As regards <u>extension services</u>, the findings revealed that the farmers feel they know more about farming than the extension technicians. They consider that the knowledge of these technicians was learned only at school, whereas theirs comes from their own experience. This may be interpreted as that their knowledge is more adaptable to their environment than these technicians. It also appears to us that the farmers are doubtful about scientific information. Their attitude towards adopting new technology is that they will do experiments first or observe the experience of other farmers. The technicians confirmed this farmers' behaviour, that they will adopt the new technology if they see the result, or in local dialect, "*kita pati ko*," which means to see is to believe.

With respect to farmers' cognition of their <u>natural environment</u>, we start with their concept of the land. According to the Kankanaey farmers, land symbolizes security for the people in the study area, as it is their source of livelihood, and therefore their life. It is also an indication of wealth, and therefore shows status quo and power. Land connects both the past and the present, for it serves as a reminder of their great forefathers. With these views on land, we may assume that the farmers will protect and conserve it in order to ensure a stable source of sustainability.

The farmers have three landscape subdivisions which we called in the study 'growing regions.' These regions are *cada*, *dagdag* and *nalamag* (see Figure 3). *Cada* includes those areas located at higher altitudes, or as the farmers described it, they are those nearly close to the mountain peaks. *Dagdag* region is the valley portion of the study area; while *nalamag* region includes those areas lying between the two regions (see Lawas, 1997 for details). Their farm practices differ in these regions, particularly between *dagdag* and *cada*.

Soil is another important component of the farmers' natural environment. They have identified seven soil types in the area such as: *linang* (red clay), *lodeg* (loam), *lagan* or *darat* (sandy soil), *paasin* (with cream colour and has a feel of a sandy soil), kenit (pit soil), *komog* (rock like soil with reddish brown colour) and *tapek* (silt). The first three types are the most frequently mentioned types by farmers. The farmers distinguished each type by colour, texture, feel when dry and also when wet, moisture retention capacity, depth and location where it is found. In addition, the farmers also recognized the suitability of each soil type to specific crops.

The farmers' views of altitude and temperature in the area is related to their growing regions. They explained that the highly elevated the location, the cooler it is; and the lower the location, the warmer.

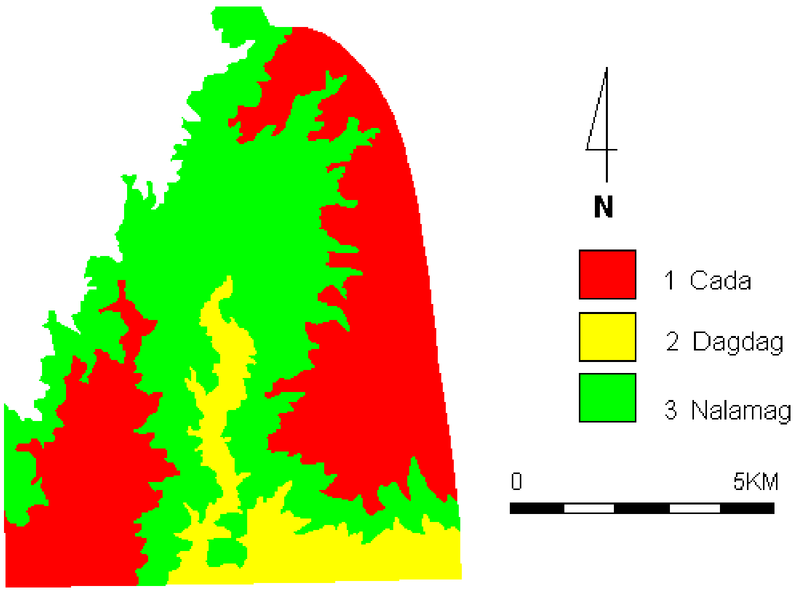

Figure 3

Map of the Kankanaey farmers' growing regions.

The farmers has also recognized the different segments of slope in the study area. They refer to it as the slanting or inclining position of an area. The farmers consider slope as a constraint, because, for example, they cannot construct wider terraces or employ their flooding system of irrigation on steep slopes. The slope segments in the study area vary from nearly flat to very steep according to the farmers. They have five slope classes: *dekkan*, *tangkilas*, *matikid* and *kayas*. *Dekkan* is equivalent to 0-8% slope classification of the BSWM, which is defined as level to nearly level or gently sloping; whereas *tangkilas* was calculated by the local agricultural staff as equivalent to 18-30% slope which is rolling to slightly steep. The *matikid* slope, however, has been equated to 30-50% slope category. The farmers described that in these areas, walking is still possible, as is cultivation and terracing, although as they claimed, the width of the terrace is narrower (but can be longer). *Kayas* areas are, according to farmers, the steepest areas and are not suitable for cultivation. They characterized such areas as those where walking is not possible, and even more impossible to terrace. It is in these areas where erosion and landslides are serious. This farmers' slope class is matched to a scientific classification of >50% slope.

Farmers have also recognized that water is an important element in their farming activities. According to water source, the farmers classify the system of farming in the study area as (a) *bankag*, or rainfed and (b) *masibugan*, or irrigated. In *bankag* system, water is obviously a limiting factor, which lowers the intensity of cropping of the farmers, e.g. two croppings per year. Under *masibugan system*, in addition to rain, water is available from the springs or creeks, and from the rivers. This availability of water allows the farmers in this system to grow crops three to four times a year. Because of these sources, the farmers said that they have been able to devise three systems of irrigating their fields. One is called *manleleyeng*, or immersion; the second is *balwek*, or impounding water in one corner of the field; and the third is "*rainbird*," or using a plastic hose with a nozzle at the end to sprinkle the water (see Lawas, 1997).

Other factors viewed by farmers as having some influence on their farming system are season, typhoon or storm, flooding or waterlogging, occurrence of crop pests and diseases, and sunlight and fogs. The impacts and how the farmers cognize these factors are given in Lawas (1997).

As shown above, the Kankanaey farmers, just like other farmers, possess a tremendous stock of knowledge about their immediate environment, which can range from economic to natural aspects of the world in which they make a living. Their knowledge is multidisciplinary in nature, which suggests the complexity of their environment and decision-making activity as well. In such a complicated world they have shown their ingenuity to adapt and make a living out of it.

Finally, our results appear to confirm our hypothesis that the Kankanaey farmers possess knowledge of their environment that is reflected in their cognition of a particular phenomenon, and that they are able to relate such knowledge to their farming behaviour. An example is their unique classification of soil. The knowledge of the farmers appears that one can use it to predict their behaviour when allocating or utilizing their resources, e.g. land. In addition, such knowledge can be an important input in designing participative development activities, which is recognized nowadays as a relevant approach in natural resource management.

2.3 Farmers' Field Utilization, Environmental Knowledge and GIS

We pursued two objectives in this case. The first is to demonstrate how spatial and non-spatial knowledge of the Kankanaey farmers can be stored, manipulated and analyzed in a GIS; and second to perform a GIS analysis in order to examine the spatial relationship between the farmers' cognition of the environment and their field utilization activities. In a specific sense, the relationship between the farmers' growing regions (*cada, dagdag* and *nalamag*), with their thematic characteristics and field utilization activities was determined. The interrelated characteristics of these growing regions included in the analysis are, for example, altitude/temperature, location and fieldtype (which can either be rainfed (*bankag*) or irrigated (*masibugan*). Field utilization activities include cropping systems, cropping intensity, cropping pattern, timing of planting, pest control, harvesting and others. The first hypothesis here is taken from the farmers' general view that their behaviour can be differentiated according to their local growing regions. The second is that farmers' knowledge can be organized and analyzed in a GIS environment. The final goal in this analysis is to confirm or validate further the rationality of the farmers' knowledge.

Methods

In order to realize the above objectives, a set of activities was followed. In the beginning of the fieldwork, the Kankanaey farmers' growing regions and their associated attributes were identified. These attributes allowed for the delineation of the boundaries of each growing regions. Both growing regions and the land management units (LMUs) of the Bureau of Soil and Water Management (BSWM), Department of Agriculture, Manila were digitized using ILWIS GIS. Farmers' field utilization techniques as indicated above were identified and attached to LMUs. This permitted us to generate attribute polygon maps, which were rasterized and related with the farmers' growing regions. To proceed with the analysis, building a database was necessary. In this respect, a conceptual data model and logical design were constructed to show how the data in the computer is organized. Thereafter, the spatial modeling program of ILWIS was used to perform map overlays between two or more maps. The outputs were then analyzed accordingly.

Summary of Results and Conclusions

A GIS was able to store, manipulate and spatially analyze farmers' field utilization and their environmental knowledge. The procedure appears to be generally applicable. From the analysis, it also appears that in general, there is a spatial relationship between farmers' field utilization activities and their knowledge of the environment, as shown by relating cropping system, cropping pattern, cropping intensity, planting practice, pest control and harvesting practice with their three growing regions (*cada*, *dagdag* and *nalamag*). Such relationships were also observed between farmers' classification of soils and their growing regions, which also confirmed their assertion that "soil types in each growing region are different." Such observed spatial relationships further validate the assumption made in the model of farmers' knowledge development that "farmers' response behaviour depends on their cognitive view of the environment." Hence, that serves in turn as proof to confirm the hypothesis stated above. Moreover, it also suggests that farmers' knowledge has a rational basis and is valid. Thus, it corroborates with the view of Howes (1979) that "localized indigenous knowledge may also provide the basis for the formulation of hypotheses which may then be referred "upward" for refinement and specific testing."

2.4 Farmers' Views of Soil Degradation and Management

Resource management is an area that requires intimate knowledge of local conditions and of ecosystems, as well as experience. It is a domain of holistic knowledge, pulling

together various technical fields where people's knowledge can be as relevant as modern specialized knowledge (Egger & Majeres, 1992). This acknowledges the importance of local or grassroots-based knowledge in resource management.
This case study is focused on the examination of the Kankanaey farmers' cognitive views of soil degradation. How its extent can be determined based on farmers' perspective is also a major concern. Soil degradation here refers to soil fertility depletion (SFD) – a decline in the inherent capacity of the soil to supply nutrients to plants – which influences crop growth and yields.

Methods

In this particular case, we discuss the qualitative assessment of Kankanaey farmers of soil degradation, soil fertility in particular.

The farmers were asked about indicators or symptoms and causes of soil fertility depletion. The conservation measures they apply as responses to the problems were also solicited. Thereafter, we tried to model and quantify the farmers' responses through the application of a GIS. Modeling was done in two ways. First by considering the responses (variables) according to the frequency of mention of each response. Second by subjecting the responses to statistical analysis 'Pearson correlation coefficient' to determine the correlations among them. The variables, which were found to correlate with soil fertility depletion, were further analyzed, using a stepwise multiple linear regression to find the best indicators and causes of soil fertility depletion.

To generate maps of the variables for modeling, we used the results from Sections 2.1 and 2.3 such as land use maps (1949 and 1980) and some maps of farmers' environmental knowledge and field utilization, respectively. An existing analogue 1995 land use map and aerial photographs were also used. The qualitative assessment of soil fertility depletion, on the other hand, was solicited through field interviews and series of house/personal visits and information discussions.

Summary of Results and Conclusions

The farmers appear to have an intimate knowledge of soil fertility depletion, as confirmed by their knowledge of its symptoms, causes and impact on crops and environment. Most of the identified symptoms relate generally to crop performance, e.g. quality and quantity of harvest, growth and soil and fertility requirements of the crops. The farmers identified seven indicators of nutrient depletion in the the soil. These are: *stunted growth of the crop*; *yellowing of leaves*, which results in wilting or drying up; *prone to and presence of diseases*, e.g. soil-borne ones; *low yield* as a result of low quality of harvest; *more fertilizer is needed than before*; *small and cracking of rootcrops*; and *soil is becoming acidic and presence of molds in the soil*. The first four indicators were the most frequently mentioned by farmers, having percentages of 86, 46, 41 and 38, respectively.

As regards the factors responsible for soil fertility depletion, the farmers cited seven factors including *soil erosion or water runoff* due to heavy or strong rains*; soil has no rest* (no fallow period); *heavy use of chemicals*, e.g. pesticides and fertilizers; *soil is old and tired* (long history of cultivation); *no crop rotation*; *immersion system of irrigation*; and *flooding or waterlogging*. The frequently cited factors by farmers are the first three ones, with 80, 68 and 67 percent, respectively.

A correlation test indicated an association between soil fertility depletion and its farmers' identified symptoms and causes, although not a strong correlation. Nevertheless, those variables with coefficients of >0.1 were used to perform stepwise regression analysis. The analysis showed that among the symptoms of soil fertility depletion viewed by the farmers, *stunted growth*, *low yield* and *presence of pests and diseases* were found to be the best indicators. Of the seven factors identified as responsible for the depletion of fertility, *soil has no rest* or fallow period and *erosion* were the best predictors.

The farmers were also able to describe the nature and causes of soil erosion. Correlation has also been detected between soil erosion and its farmers-perceived causes. Of the nine variables subjected to correlation analysis, only five have coefficients of either >0.1 or >-0.1. When subjected to regression analysis, these five factors remained good predictors of soil erosion as perceived by the Kankanaey farmers.

Based on such analysis, GIS modeling was also carried out to calculate the extent of soil degradation in the area according to farmers' perspective. Two approaches were considered: one based on the direct response of the farmers, and the second based on the results of regression analysis. The result based on direct response of the farmers shows that about 76% of the study area is either moderately or highly degraded. This percentage went up to 79% when modeling was based on the result of the regression analysis. The difference is insignificant, so both approaches are comparable. Considering only the highly degraded category, it appears that soil degradation is serious as almost half of the area belongs to this category. This is particularly so when the approach was based on direct response of the farmers. In addition, this finding has been made possible through incorporating both scientific methods and farmers' knowledge, which proves that farmers' or any other grass-root-based knowledge can be processed, analyzed and presented in the same way as scientific knowledge. We assume therefore that it can pave the way for the maximum utilisation of such knowledge in resource management planning and decision-making at all levels, i.e. national, regional, provincial, or local and village levels.

Finally, such knowledge of the Kankanaey farmers on soil fertility depletion and erosion seems to address our hypothesis "that just like those farmers elsewhere in the world, they are also capable of knowing and perceiving soil degradation or soil fertility depletion."

The farmers, who are always beset by the micro-conditions above, have to find measures to alleviate if not totally solve them. Maintaining the fertility of the soil, for instance, requires some efforts to ensure stable harvests. Soil erosion has to be minimized in order to prevent continuous loss of soil fertility. For soil erosion control, the farmers have to be always sure that their fields are terraced, which can be walled either using earth or stones. Stone walling, or *kabite* in the local dialect, is the most preferred way of stabilizing the terraces. Apart from terracing, other control measures are construction of diversion canals, planting of grasses or shrubs on the edges of the terraces and others. In addition to controlling erosion, the farmers also adopt other measures to sustain the fertility of the soil: application of chicken dung, inorganic and organic fertilizers and lime; green manuring; soil excavation or bulldozing; composting; and crop rotation.

2.5 Spatial Crop Decision Behaviour of the Farmers

The Kankanaey farmers grow various kinds of vegetable crops, some of which they cultivate regularly in a year and others they plant alternately. They can have as many as three to four croppings per year on the same field. In this situation, i.e. with a complex environment, they need to know a lot about plant production in order to come up with the best choice of crop or combination of crops to grow. This implies that to study their decision behaviour is quite a difficult task.

In this particular case, two issues have been addressed: (a) to determine and analyze the farmers' perspective of choosing crops and their spatial dimension; and (b) to link the result of multivariate analysis (principal component analysis) with a geographic information system.

We did not consider here any particular model or theory of decision-making, as it will force us to construct a set of procedures which only fits that model or theory. Thus, to understand the actual choice behaviour of the Kankanaey farmers, we studied this matter with an open mind and, instead formulated the following assumptions:

- Kankanaey farmers as vegetable growers are planting different crops and the problem is how to choose the best crop (alternatives);
- Kankanaey farmers have certain, more-or-less defined objectives to achieve (objectives);
- Kankanaey farmers have a set of criteria or factors which they considered important in their actual choice of crops to grow (criteria);
- The factors considered constitute how they perceive their environment and are interrelated to each other (farmers' environment); and
- The farmers' perception of what he or she has decided will satisfy his or her objectives (aspiration).

Methods

To analyze the most and the least preferred crops by the farmers, the various crops that they cultivate were ranked. This was done by computing the relative weights (expressed in percentages) of farmers' behaviour, *always growing* (at least once a year) and *sometime growing* (a crop is not often grown in a year) for each crop. The interest here is to know which crop is always grown by farmers at least once a year. The factors associated by farmers to their choice of crops were analyzed using the factor listing approach. This approach is based on three considerations: (a) asking the farmers the major criteria or factors they consider important in selecting the crop they want to grow; (b) counting the number of times each factor is mentioned and calculating the percentages; and (c) assuming that the percentages represent the factors' importance. Percentages are considered as weights of each factor.

It should be remembered that the farmers were asked about the factors they usually consider important according to land management units (see Section 1.4). The overall and extent of importance of each factor was determined from the affirmative responses of the farmers per land mapping unit using the formula:

WAR = AR/N (100)
where
WAR - weight of affirmative response
AR - affirmative response
N - total number of farmers per land mapping unit

In order to know the interrelationships among factors identified by farmers, and which among them can be grouped together, multivariate analysis was employed. Principal component analysis (PCA) was specifically chosen. The results of the PCA were obtained using computer-based statistical software SYSTAT (Wilkenson et al., 1992).

Summary of Results and Conclusions

The major crops of the Kankanaey farmers (in order of importance) are potatoes, Chinese cabbage, cabbage, lettuce and carrot. The farmers grow two or more crops per year. In broad terms, their objective in cultivating these crops is "*to produce more in order to have more income*." This objective has sub-objectives which include subsistence, education, good food and shelter, and acquiring farm implements, as well as a vehicle to transport their harvests. The farmers also named several factors they considered important in deciding which crop to cultivate. Among these factors, seven were used for the analysis as they were considered by a large percentage of farmers. These include season, market price, income derived from the crop, soil, climate, occurrence of pests and diseases, and availability of planting materials. Except for soil, the other factors can be considered as those over which the farmers have no direct control. This may be one of the reasons why farmers consider vegetable farming as a "gamble" – meaning a risky business. We may also say that farmers make their decisions under uncertain conditions. Likewise, owing to the nature of their broad objectives, their decision behaviour appears partly incorporates the profit maximization models of decision-making.

The result of the application of multivariate analysis, e.g. principal component analysis, shows the groupings of the crop decision behaviour of farmers. Two component groupings of factors were considered. Each component provides the highest and lowest values, which determine what specific factors are important to that component. The *first* component factors consist of bipolar factors, which means that the highest coefficients have positive and negative signs. The group of factors with positive sign were interpreted as being economic factors, e.g. market price and income, while those with negative signs were seen as physical factors, e.g. soil and season. The *second* component is concerned with biological and microclimatic factors, e.g. pests and diseases, and microclimate in the area.

The findings indicate that the crop decision behaviour of the farmers can be grouped into a few components, which make the interpretation easier. The analysis further permits the presentation of such behaviour in a quantified and spatial form by linking GIS, which could facilitate better understanding. In addition, the analysis further demonstrated the spatial dimension of the farmers' crop decision behaviour.

2.6 Information Integration

This case study has two aims: (a) to integrate the information generated in previous cases, including that which has been collected from the farmers and from scientific-based sources; and (b) to compare and relate spatially some of the farmer-based information with other information, including that which is scientific-based.

The analyses carried out among information types were performed in three combinations:

- farmers-based to scientific-based information;
- scientific- to scientific-based information; and
- farmers to farmers-based information.

In the first combination farmers-based information is compared and matched with that scientific-based information. In the second combination, the scientific-based information is related with other scientific information. Similarly, in the third combination, the farmers-based information is analyzed in relation to other information from the same domain.

In all three combinations, the assumption is that the results will give scenarios about the relationship between information from the two knowledge systems. For example, 'Are there similarities or differences between both knowledge systems with respect to perceiving phenomena?' More specifically: 'Can we observe whether there is a difference between the BSWM soil classification and that of the Kankanaey farmers?' In addition, we also assumed that we will be able to create scenarios to confirm the qualitative responses of the farmers, while also demonstrating further that their behaviour is dictated by how they perceive their environment. Moreover, the analyses were carried out to test and implement the logical data model constructed for the integrated resource users- and scientific-based information system (IRUSIS).

2.7 Steps in the Integration Process

Information integration in a GIS is not a straightforward process. It requires a great deal of painstaking work. To prepare for the integration process, the first step carried out was to construct a data model that would show the different information types and their organization in the integrated resource users- and scientific-based information database (see Figure 4). The next step was to check the compatibility of the information and implement the data model - which meant combining all information into a single database. Thereafter, analysis (spatial) proceeded. Overlaying, which included map calculation and using crossing module of ILWIS GIS, was the main approach used in matching and relating information types.

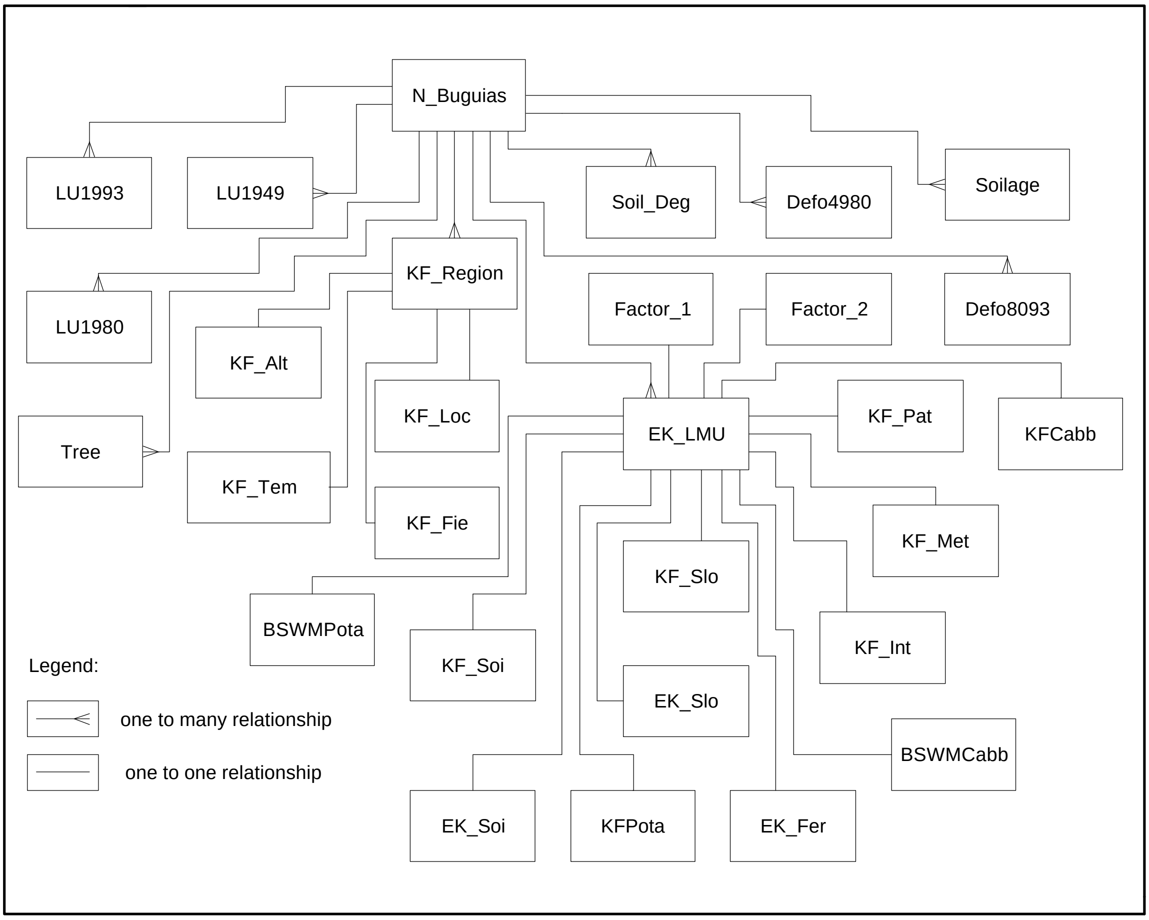

Figure 4 Logical design for the integration of farmers- and scientific-based information. Note that the meanings of the items in the figure are given in Annex 1.

2.8 Matching and Assessing Relations Among Information Types

Most important in this analysis, from our point of view, is the relationship between farmers-based and scientific-based information. Another point is to demonstrate that farmers' perception can be incorporated with a scientific perception of reality. In addition, our intention here is to confirm some farmers' assertions that may enhance the reliability of their knowledge. Lastly, we wish to show by example whether the spatial relationship that exists between and among scientific-perceived phenomena can also be observed in farmers' perspective.

Farmers- to scientific-based information. The first combination of information that was analyzed here is about the farmers' and the BSWM classification of soil by growing regions (farmers' subdivisions of the landscape). According to BSWM, in general the three growing regions have medium to fine soils, whereas according to farmers' perspective the valley areas (*dagdag*) consist of both clay loam (*linang lodeg*) and sandy clay (*lagan linang*) or sandy loam (*lagan lodeg*) or sandy clay loam (*lagan linang lodeg*); *nalamag* and *cada* regions have clay loam (*linang lodeg*) soils.

Careful examination of soil types present in the study area from both perspectives reveals that the farmers' classification falls under the medium to fine classification of the BSWM (Table 1), which can be further subdivided into what the farmers' have. Hence, it appears that the BSWM classification is broader and general, while the farmers' classification seems more refined and detailed.

Table 1 Percentage distribution by farmers' growing regions of the soil types from two knowledge perspectives

Soil Class	Farmers' Growing Regions		
	Cada	Dagdag	Nalamag
BSWM Soil			
Medium	10	3	28
Medium to fine	90	97	72
Farmers' Soil			
Lagan-linang or lodeg	0.56	46	13
Linang lodeg	77	48	59
Lodeg	23	6	28

The BSWM fertility status of the soil in the area was also matched with the result of modelling farmers' perception of soil degradation, which was interpreted in this study as soil fertility depletion. The finding shows that areas with low fertility according to BSWM were almost equally distributed among slightly, moderately and highly degraded areas of the farmers (see Table 2). Areas with medium fertility correspond with moderately degraded areas, but those with high fertility are – surprisingly – highly degraded areas. The discrepancy in this last case may be due to the fact that the BSWM fertility assessment was taken from a report which is more than 10 years old. Then forest was still the dominant land use (particularly in *cada* region), thus soil fertility loss was not much an issue.

Table 2 The BSWM fertility classes in relation to soil degradation classes as modelled from farmers' perception

BSWM Fertility Classes	Modeled Farmers' Perception of Soil Degradation Classes		
	Slight	Moderate	High
Low	34	38	28
Medium	6	57	27
High	0	12	88

The result on relating the BSWM slope classes to farmers' perception of soil degradation (soil fertility depletion) shows that most of the areas with 0-3% slope are highly degraded in the opinion of the farmers; those with 3-8% are moderately degraded; and those with 30-50% are also highly degraded. Those areas of >50% slope, however, are moderately or slightly degraded. This appears to indicate that the notion that the steeper the location the lower its fertility of the BSWM is not correct, hence it demonstrates the differences between farmers' and scientists' perception or understanding of reality.

Field suitability according to farmers' assessment was also compared with that of the BSWM assessment. Overall, most of the areas in the study area were rated by the BSWM as not suitable for potato, cabbage and carrots; whereas the farmers assessed most of them as moderately to highly suitable, not only for the three crops but also for other temperate vegetables (see Table 3). Here, there is a big gap between farmers' and BSWM perception. There are probably two reasons for this: one is that assessment of the BSWM is out of date as it was done more than 10 years ago, and the other is that farmers have changed the land by terracing, applying organic and inorganic fertilizers, etc.; proven the suitability of those crops in their fields by producing tons of vegetables every year.

Table 3 Field suitability assessment of the BSWM and of the farmers (% of area) for cabbage, potato and carrots

	Farmers		
BSWM	**Highly Suitable**	**Moderately Suitable**	**Marginally Suitable**
Cabbage			
Highly suitable	0	10	0
Moderately suitable	10	0	0
Not suitable	90	90	100
Potato			
Highly suitable7 --	7	-	-
Moderately suitable	2	-	-
Not suitable	91	-	-
Carrot			
Moderately suitable	-	7	0
Not suitable	-	93	100

Relating the state of deforestation in the area for the periods 1949-80 and 1980-93 with the farmers' growing regions was further undertaken. Deforestation in this case was calculated using the overlay and "rule base" procedures, i.e. *if*, *then*, *else* expression in a GIS. The areas which have been converted from forest to other uses were identified as deforested areas. The purpose here is to find out and understand in which growing regions most deforestation took place in those periods. This will check the farmers' ability to recall important events.

The result from the overlay of deforestation and farmers' growing regions shows that in the period 1949-80 a high percentage of deforestation took place in the *nalamag* (location next to valley areas) and *cada* regions (the high altitude region). In the period 1980-93, however, deforestation was concentrated mainly in the higher areas or *cada.* This suggests that in general, deforestation in the area followed a linear trend, starting in the flat areas, where settlement began, then to the upper region next closest to it, and finally to the highest and farthest areas. It also corroborates with the farmers' claim that forest denudation started in the lower part, then moving up to the highest region.

The farmers attributed the loss of forest to increasing population, which has resulted in the great demand for land to be farmed. Related to this is the lucrative nature of vegetable industry, which is considered more profitable than other alternative crops.

With respect to land use and the farmers' growing regions, in 1949 forest was the dominant land use in all regions. By 1980, forested areas had declined and the remaining forest could only be observed primarily in the *cada* region and some portion of the *nalamag* region. This situation continued until 1993, when *nalamag* region was the location of most deforestation. At present, can be seen mostly in *cada* region.

As regards agricultural areas, in 1949, they were concentrated in a small portion of the *dagdag* region (valley). This had expanded enormously by 1980 to other regions, particularly in the *nalamag*. By 1993, almost all regions had been transformed to agriculture. In fact, today, only in *cada* region do spots of forests remain. This scenario contrasts with forest land use. Generally, the situation appears to illustrate that land use dynamics depends on location.

<u>Scientific- to scientific-based information</u>. Here, the BSWM slope classes were compared with deforestation and land use. The findings appear to show that deforestation in the area started in the flat areas, then expanded to the less steep areas and continued to even the steepest areas (>50% slope). With regards to land use, the result shows that in 1949, agriculture started in a small portion of nearly flat areas, while forest dominated in all other slope ranges. But by 1980, most of the areas whose slope range from 3-50% had been converted to agricultural use and only those with >50% had a greater percentage of forest. By 1993, however, these areas had also been transformed to agriculture. This situation seems to imply that the stages of the transformation of forest to other uses, particularly agriculture, are related to slope. The less steep the area, the easier and faster the transformation.

<u>Farmers- to farmers-based information</u>. The analysis carried out here intends to show that the farmers' understanding of some components of their environment can be spatially related to each other. From the result, an impression can also be gained about the logical basis of the knowledge system.

The farmers' understanding of soil degradation and crop decision behaviour were matched and compared here with their growing regions. The results for soil degradation and farmers' growing regions show that the cada region falls under the category "slightly to moderately" degraded areas, whereas the dagdag and nalamag regions fall under "moderately to highly" degraded areas according to farmers' perception of soil degradation. In this case, it seems that this result could be related to the history of cultivation, which means that the longer the area has been subjected to cultivation the more degraded it is.

The spatial analyses carried out showed that with information integrated in a single database, it is easier and faster to compare, or match or relate different information types. For example, the information derived from the farmers' perspective can be immediately compared and related to scientific information. This also implies that information can be retrieved at anytime, thus making information more accessible. Additional information can be further integrated into the database.

Likewise, the analyses of the comparisons of the information from the two knowledge domains reveal some similarities and differences in perceiving a particular phenomenon or reality. As such, some of the farmers' perceived relationships between phenomena were confirmed. For example, the relationship between their growing regions and the state of deforestation in the study area.

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ANNEX 1. **Type and source of data included in the data model (see Figure 4) for information integration.**

Type	Abbreviation	Source
Land use 1949	LU1949	1949 aerial photos; scale: 1:50,000
Land use 1980	LU1980	1980 aerial photos; scale: 1:60,000
Land use 1993	LU1993	1993 Land Sat TM
Deforestation 1949-1980	Defo4980	Land use maps 1949 and 1980
Deforestation 1980-1993	Defo8093	Land use maps 1980 and 1993
Land management units	EK_LMU	BSWM updated 1995 land management units analog map
Farmers' crop decision criteria	Factor_1 and Factor_2	Fieldwork/farmers
Farmers' assessment of soil degradation	Soil_Deg	Fieldwork/farmers
Farmers' growing region	KF_Region	Fieldwork/farmers
Altitude range in each growing region	KF_Alt	Fieldwork/farmers
Associated temperature of each growing region	KF_Tem	Fieldwork/farmers
Associated field type in each growing region	KF_Fie	Fieldwork/farmers
Location of each growing region	KF_Loc	Fieldwork/farmers
Farmers' soil class	KF_Soi	Fieldwork/farmers
BSWM soil class	EK_Soi	LMU analog map
BSWM slope	EK_Slo	LMU analog map
Farmers' slope class	KF_Slo	Fielwork/farmers
BSWM fertility class	EK_Fer	LMU analog map
Farmers' cropping pattern	KF_Pat	Fieldwork/farmers
Farmers' cropping method	KF_Met	Fieldwork/farmers
Farmers' cropping intensity	KF_Int	Fieldwork-farmers
BSWM suitability assessment for potato	BSWMPota	BSWM old LMU analog map
Farmers' suitability assessment for potato	KFPota	Fieldwork/farmers
BSWM suitability assessment for cabbage	BSWMCabb	BSWM old LMU analog map
Farmers' suitability assessment for cabbage	KFCabb	Fieldwork/farmers
Extent of forest	Tree	BSWM 1995 land use analog map
History of cultivation of the field	Soilage	Fieldwork/farmers; land use maps 1949, 1980 and 1995