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Science, Myth and Knowledge: Testing Himalayan Environmental Degradation in Thailand

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Abstract: This paper examines recent debate concerning the concepts of 'sustainable knowledge' and 'hybridity' in environmental research. Hybrid studies employ local, indigenous knowledge alongside global, scientific techniques to achieve guidelines for sustainable development. The paper discusses the value of indigenous knowledge in testing theories of environmental degradation, and the problems of overcoming socio-political constructions of environmental problems over wide time and space scales, as identified by Regional Political Ecology. The paper focuses on the so-called theory of Himalayan environmental degradation and illustrates the study with a case from northern Thailand. In Thailand, upland shifting cultivators are blamed for causing lowland sedimentation and water shortages, and have been considered by lowland communities to lack awareness of environmental degradation. The study used indigenous knowledge alongside GIS analysis and the Caesium-137 technique for measuring soil erosion to test the assumptions that land shortage has increased cultivation on steeper slopes, and that erosion is a problem for upland degradation. This is the first time these new techniques have been used in testing assumptions related to Himalayan degradation. Results indicated that upland farmers deliberately avoid erosion by increasing frequency of cultivation of flatter slopes rather than steeper slopes, and consequently the problem of erosion is overstated. However, this does not imply that their local knowledge is useful over larger areas, but instead shows the adaptability of local communities and their awareness of environmental risk. It is therefore argued that developing effective management techniques depends on differentiating more clearly between locally-based knowledge about environmental processes; politically-constructed statements about the environmental impacts of other groups; and falsifiable scientific assertions aiming to develop effective management techniques with reference to several communities.

Introduction

In a recent paper, Murdoch and Clark (1994) argued for a 'hybrid' approach to studies of sustainable-development, in which scientific and indigenous knowledge about environmental degradation are combined. This approach was argued to be more accurate in assessing human experience of environmental problems, as well as giving insight into the power relations between indigenous knowledge and science in the formulation of environmental policy. Although Agrawal (1995) has warned that it may be folly, or even damaging to minorities, to separate the categories of 'indigenous' and 'scientific/western' too far, an increasing number of geographers are using hybridity in their assessments of environmental degradation (e.g. McGregor and Barker, 1991; Scott and Walter, 1993; Sillitoe, 1993).

Such hybrid studies have been applied in recent years to the so-called 'Himalayan Environmental Degradation Theory' (Ives and Messerli, 1989). Originally advanced during the 1970s to explain accelerating

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deforestation and soil erosion in the Himalayas, the so-called theory is now a symbol of how scientific approaches to environmental degradation have changed. Similar to concerns about desertification (Biot *et al.*, 1992; Thomas and Middleton, 1994), environmental researchers now see the supposed Himalayan crisis as partly constructed by political and social factors rather than the result of proven and tested physical processes. As a consequence, many of the original assertions about environmental degradation in the Himalayas have been called 'myths' or 'falsehoods' (Metz, 1989, 1991), and scientists increasingly consult indigenous knowledge to indicate environmental degradation.

Yet indigenous knowledge may too be branded 'mythology' because it is one culture's experience and wisdom (Thompson, 1989; Young, 1990), and 'falsehood' because it is too locally based to be aware of potential environmental impacts downstream. While Regional Political Ecology (e.g. Blaikie, 1985; Blaikie and Brookfield, 1987; Bryant, 1992) has recognised the importance of such social perspectives and conflicts in constructing environmental problems, the problem still remains of developing practical environmental management techniques which avoid spatial, temporal or cultural bias.

Hybrid studies may present a way forward, as the use of indigenous knowledge alongside scientific techniques may allow each to verify the other, and provides an indication of the ability to widen the application of local practices. This paper examines hybridity further, particularly regarding the so-called Himalayan environmental degradation theory. A case study is used to illustrate the discussion, using evidence from northern Thailand, in which indigenous knowledge from historic shifting cultivators was used with scientific techniques to test long-standing assumptions that land shortage has caused greater cultivation of steep slopes, and that erosion is a major cause of environmental degradation for hill farmers.

Myths and Science: the Testability of Himalayan Degradation

Perhaps the most controversial aspect of the so-called Himalayan environmental degradation theory is that it is commonly referred to as a 'theory', yet in reality is more of a framework than a testable hypothesis. Like the debate surrounding desertification, Himalayan degradation began to be targeted as a problem during the 1970s at a time when western science increasingly began to question the benefits of modernisation and the impacts of humans on resources which were perceived to be fragile or in short supply (e.g. Meadows *et al.*, 1972). As with desertification, Himalayan degradation involved a series of human actions and physical processes which were intuitively attributed, via a series of thresholds, with causing environmental problems. Yet testing this 'theory', in the manner of traditional positivism, has essentially been impossible because of the role of human perceptions, and the complexity and scale of physical processes involved. Science is understandably confused.

One key theme has been the role of 'myths' in the theory. Myths have been used to refer to some of the initial assumption about the nature and extent of the problem which were made by scientists on the basis of very little evidence (Metz, 1989, 1991; Hofer, 1993; Thomas and Middleton, 1994). Yet in addition, myths have been used to describe the indigenous knowledge of some communities which have either been blamed for causing degradation, or heralded as having extra insight into the nature and extent of the problem (Thompson, 1989). Myths may therefore be seen as 'falsehoods', or as cultural devices which captured, in elegant and simple form, some essence of experience and wisdom. The assessment of Himalayan environmental degradation has therefore been based largely on the side-by-side use of far-reaching, yet inaccurate scientific assumptions; judgemental condemnation of certain communities for increasing degradation; and consultation of indigenous knowledge for a supposedly 'greener' or more accurate approach (Murdoch and Clark, 1994). However, the diversity of knowledge generated on the topic of environmental degradation has arguably resulted in a greater inability to test the problem, or to devise effective management strategies applicable over large areas.

Early Himalayan environmental degradation theory is now generally considered to have produced the greatest number of scientific myths or false assumptions (Ives and Messerli, 1989; Metz, 1989, 1991). The 'theory', as it emerged through a variety of texts (e.g. Eckholm, 1976; Blaikie *et al.*, 1980; Lall and Moddie, 1981), described how the supposedly fragile ecosystem of the Nepalese Himalaya had undergone environmental degradation as a result of rapid social and economic change following from population increase and modernisation. After centuries of no contact with the rest of the world, Nepal opened its borders in the 1950s to international trade, commercialisation and the demographic transition. Rapid population growth resulting from reduced malaria and immigration led to an increasing land shortage in the lowland *Terai* and so-called Middle Hills, which were the foothills to the Himalayan mountains. This land shortage led more and more farmers to cut trees in search of fuelwood and agricultural land, which in turn was argued to lead to landslides and soil erosion. This land degradation caused further shortage of land, and also led to unwanted downstream impacts such as sedimentation and flooding, even as far east as Bangladesh.

The emphasis on neo-Malthusian environmental crisis was well summarised in one (now famous) quotation, which stressed how land shortage caused degradation by forcing more and more farmers onto ever steeper slopes. Eckholm (1976, p. 77) wrote:

> Population growth in the context of a traditional agrarian technology is forcing farmers onto even steeper slopes, slopes unfit for sustained farming even with the astonishingly elaborate terracing practised there. Meanwhile, villagers must roam further and further from their houses to gather fodder and firewood, thus surrounding villages with a widening circle of denuded hillsides.

Revised scientific approaches to the problem arose when empirical surveys indicated that rates of erosion or deforestation were not as serious or uniform as originally thought (Thompson *et al.*, 1986), and also as a result of anthropological studies which indicated that many communities did not experience environmental degradation as predicted. Such studies revealed that many farmers could adapt to the problems of erosion or landslides by developing indigenous technology to reduce the impact of processes on agricultural production (e.g. Johnston *et al.*, 1982; Filpi *et al.*, 1983; Gurung, 1989). The deconstruction of the environmental crisis was probably best illustrated by the realisation that some farmers triggered landslides themselves as a mechanism to renew soil fertility (Kienholz *et al.*, 1984; Ives and Messerli, 1989, p. 90; Metz, 1991, p. 810). This suggested that the supposed environmental crisis in the Himalayas was in fact a western construction reflecting anti-modern environmental concerns of the west at the time (Bjønness, 1986), and that local indigenous knowledge may be sufficient to manage environmental problems.

The impact of these realisations was the partial deconstruction, or falsification, of some the early assumptions of environmental crisis made in Himalayan environmental degradation theory, and instead a change of focus onto the management, or allocation, of degradation. Although the significance of degradation for upland communities had been downgraded, lowland dwellers still experienced problems of sedimentation and water shortages. Many such lowland communities claim that the triggering of landslides, or any other activity which produces erosion, are irresponsible acts by upland farmers because they cause sedimentation. Conflicts like these may occur in areas where previously migrant shifting cultivators have become permanent settlers on account of land shortage, yet resist adopting new soil or forest-conservation measures because their culture has not experienced long-term problems of soil erosion resulting from cultivation of the same land for many years (e.g. Conklin, 1954).

The different experience of environmental problems by various communities may therefore impact upon assumptions about degradation and research undertaken on account of the different power of the communities. Lowland dwellers, who are more likely to have better quality land and integration in the state than uplanders may therefore still influence supposedly objective approaches to environmental problems on the basis of their perception. This problem of variable perspectives of indigenous knowledge on degradation was approached by Thompson *et al.* (1986) in the use of 'trans-science' (Weinburg, 1972). They argued that such different power relations between opposing perspectives on the same problem has led to institutionalisation of research and opinions, resulting in a changed emphasis of science from simply asking "what are the facts?" to a search for evidence for particular perspectives by asking "what would you like the facts to be?". Such new science, which attempts to consider the power of perspectives, as well as the nature of physical processes, may emerge to be the mechanism through which management or allocation decisions are made.

Regional Political Ecology has extended this approach into a wider analysis of how political issues of access to resources and conflict between communities may influence construction of environmental problems and policies for management (e.g. Blaikie and Brookfield, 1987; Blaikie, 1988; Black, 1990; Bryant, 1992; Hoben, 1995). Under this approach, the aforementioned statements of lowlanders against upland shifting cultivators are seen to reflect historic perceptions of minorities as external to the state or threatening (Blaikie and Brookfield, 1987, p. 243). Lowland majorities are therefore likely to see indigenous knowledge from shifting cultivators about the need for soil and forest-conservation as 'myths' because they are too locally or temporally based, and also degrading to resources that lowlanders value. Yet in scientific terms, the assumptions of environmental policy devised in these circumstances by lowlanders may themselves be called 'myths' (or falsehoods) because they have not been developed in the wake of scientific enquiry, but in response to political needs. Indeed, research into watershed management has indicated that common lowland fears about erosion and water shortages resulting from shifting cultivation are unproven (Nortcliffe and Dias, 1988; Hamilton, 1988; Hamilton and Pearce, 1988).

The resulting politicisation of perception and knowledge has led to further study of institutionalisation of perceptions, and political power attributed to certain perspectives above others (Ritterbush, 1971; Ziman, 1971; Laudan, 1982; Thompson *et al.*, 1986), and the healthy growth of Regional Political Ecology to include a critique of western assumptions in the power relations of knowledge (Shiva, 1991; Murdoch and Clark, 1994; Agrawal, 1995; Jewitt, 1995). 'Hybridity' is a proposed solution to the dilemma of seeking solutions to environmental problems with a balance between western and indigenous viewpoints (although Agrawal warns against disempowering local communities by commoditising them or their knowledge). However, this may be little more than a social or environmental application of the long-established physical-science technique of "multiple working hypotheses" (Haines-Young and Petch, 1985). Some testing mechanism is still required in order to evaluate the sustainability of perceptions, and the accuracy of assumptions.

Traditional statistical, or positivistic, testing of the assumptions of Himalayan environmental degradation theory have ended in failure at the large, or even smaller scales. Looking at river discharge, precipitation, and flooding, rather than sedimentation, Hofer (1993) found no statistically-significant relationships for some major watersheds between Nepal and the Gangetic plain. At a smaller scale, Smadja (1992) found no direct relationship between deforestation or precipitation with erosion on one Nepalese slope. However, studies seeking evidence to support falsification, rather than simply testing the statistical strength of observed relationships, have had greater success. Thapa and Weber (1995), for example found evidence in Nepal that hill farmers avoid steep slopes, and consequently have not accelerated deforestation in recent years, in apparent contradiction to the above prediction of Eckholm (1976, p. 77). Similar geomorphological studies of human activities have questioned the importance of erosion in causing degradation (e.g. Harden, 1993; Nortcliffe and Dias, 1988) or the impacts of deforestation on erosion and water shortages (Hamilton, 1988; Hamilton and Pearce, 1988; Froehlich and Starkel, 1993).

Hybridity may therefore strengthen the ability to test Himalayan degradation because it allows indigenous knowledge to be used as an additional source of information (McGregor and Barker, 1991; Sillitoe, 1993). Furthermore, it may improve management because it draws on the knowledge of local inhabitants (Scott and Walter, 1993). However, such studies have only been conducted at small spatial scales, and have tended to use local knowledge to falsify scientific assumptions, rather than draw into question the applicability of indigenous knowledge for management schemes relating to wider areas and numerous social groups.

The bias towards testing western assumptions rather than local knowledge may be because assumptions are already in a testable framework and can therefore be falsified more easily. However, it may also reflect a political trend among researchers to favour local knowledge as more sustainable than western science (Murdoch and Clark, 1994). This has consequently raised concern among those who wish to construct an accurate and usable environmental plan which integrates perspectives from various sectors of society, and those who see the romanticisation (or 'othering') of indigenous knowledge as inaccurate and potentially damaging to minorities' standing in society (Agrawal, 1995; Jewitt, 1995).

Hybrid testing of environmental degradation therefore faces the dilemma of attempting to improve the accuracy of scientific knowledge about degradation, while not adding to the myths by overstating the importance of indigenous knowledge. The problem is illustrated in Thailand, where the principles of early

Himalayan environmental degradation theory have influenced government environmental policy in the uplands.

Myths and Degradation in Upland Thailand

The mountains of northern Thailand provide an opportunity to illustrate the study (see Figure 1). Northern Thailand is neither as high nor tectonically active as the Nepal Himalaya, and is hydrologically different to Nepal through having no glaciers or ice to store water which can be released during the dry season. However, the region is commonly considered to be within the eastern extremity of the wider Himalayan region (Ives and Messerli, 1989, p. 16), and has had a variety of studies undertaken within the context of Himalayan environmental degradation theory (Kunstadter *et al.*, 1978; Ives *et al.*, 1980; Hurni, 1982). Ives (1980, p. 10) repeated the concerns of Eckholm (1976, p. 77) when he wrote about northern Thailand.

> Serious land shortage has reduced the traditional periods of forest fallow so that the old systems are on the verge of collapse. Soil erosion, decreasing soil fertility, progressive deforestation and spread of *Imperata* grasslands are all contributing to a critical situation in the mountains, which also has increasingly heavy impacts on the settled agricultural systems of the lowlands.

The relationship between upland and lowland in northern Thailand has been crucial in the region's history, and is reflected in political and environmental policy. The first T'ai kingdoms (or *mu'ang*) were established in intermontane basins in northern Thailand in the late thirteenth century, and these became dependent on irrigated rice grown with the *mu'ang fai* system of irrigation to manage water supply during the long dry season, typically November to May (Wittfogel, 1957; Van Roy, 1971; Demaine, 1978).

The upland regions surrounding basins were typically inhabited by ethnic minorities such as the Karen, who have lived in the region for as long as the T'ais, and in the last two centuries by migrant groups from Burma, China and Laos such as the H'mong and Yao (McKinnon and Vienne, 1989). Classically, although most upland farmers practised shifting cultivation, long-term residents such as the Karen used 'rotational' techniques, which rotated swidden plots around semi-permanent villages; and the migrants were 'pioneer' shifting cultivators, who cultivated plots without fallow for 10–20 years, often growing opium, before moving to a new village site (Geddes, 1976; Grandstaff, 1980). Although it can be claimed that both types of cultivation are ecologically sustainable if sufficient space and recovery time are available, land shortage in Thailand has meant that most 'pioneer' cultivators are no longer able to relocate villages, and hence are now experiencing long-term problems of declining soil fertility for the first time.

For over a century, lowland T'ai communities have blamed hill farmers for environmental problems such as deforestation, water shortages and sedimentation (Warrington-Smyth, 1895; Oughton, 1971; Janawat, 1985; Wunpiyarat *et al.*, 1995). Until the national logging ban in 1989, Thailand experienced one of the world's worst rates of deforestation (put at 3.15% per year in 1982 by FAO/UNEP, in Allen and Barnes, 1985), and increasingly, lowland communities see reforestation of the upland north as the main way to avoid water shortages (such as the major drought of 1994) or flash flooding (as experienced in 1995) as far south as Bangkok (Tangtham and Chunkao, 1990).

However, such policy has been criticised by anthropologists who claim reforestation and resettlement of upland villages do little more than reflect centuries of resentment of hill communities by lowlanders, and the desire of the state to gain military control over strategic high land near the country's borders with Burma and Laos (Hearn, 1974; Race, 1974; Tapp, 1986; McKinnon, 1977, 1986). In addition, environmental groups in Thailand have also pointed out that some government schemes to plant monocultures of teak, pine, or eucalyptus in the uplands do little to restore biodiversity and are more likely to be linked to profiteering by officials (Hirsch, 1990; PER, 1992; Elliott *et al.*, 1994; Stott, 1991).

Such wider, political concerns may impact on environmental management schemes by encouraging the use of principles that are considered by many researchers elsewhere to be 'myths' or 'falsehoods' (McKinnon, 1983). For example, much research on watersheds elsewhere in Asia has indicated that reforestation may decrease the total outflow of water rather than increase it (e.g. Hamilton, 1988; Hamilton and Pearce, 1988). This may refer to usable surface water as well as deeper baseflow which may need the use of bore holes or other technology to access it. Furthermore, other research has implied upland agriculture may not be as relevant to lowland

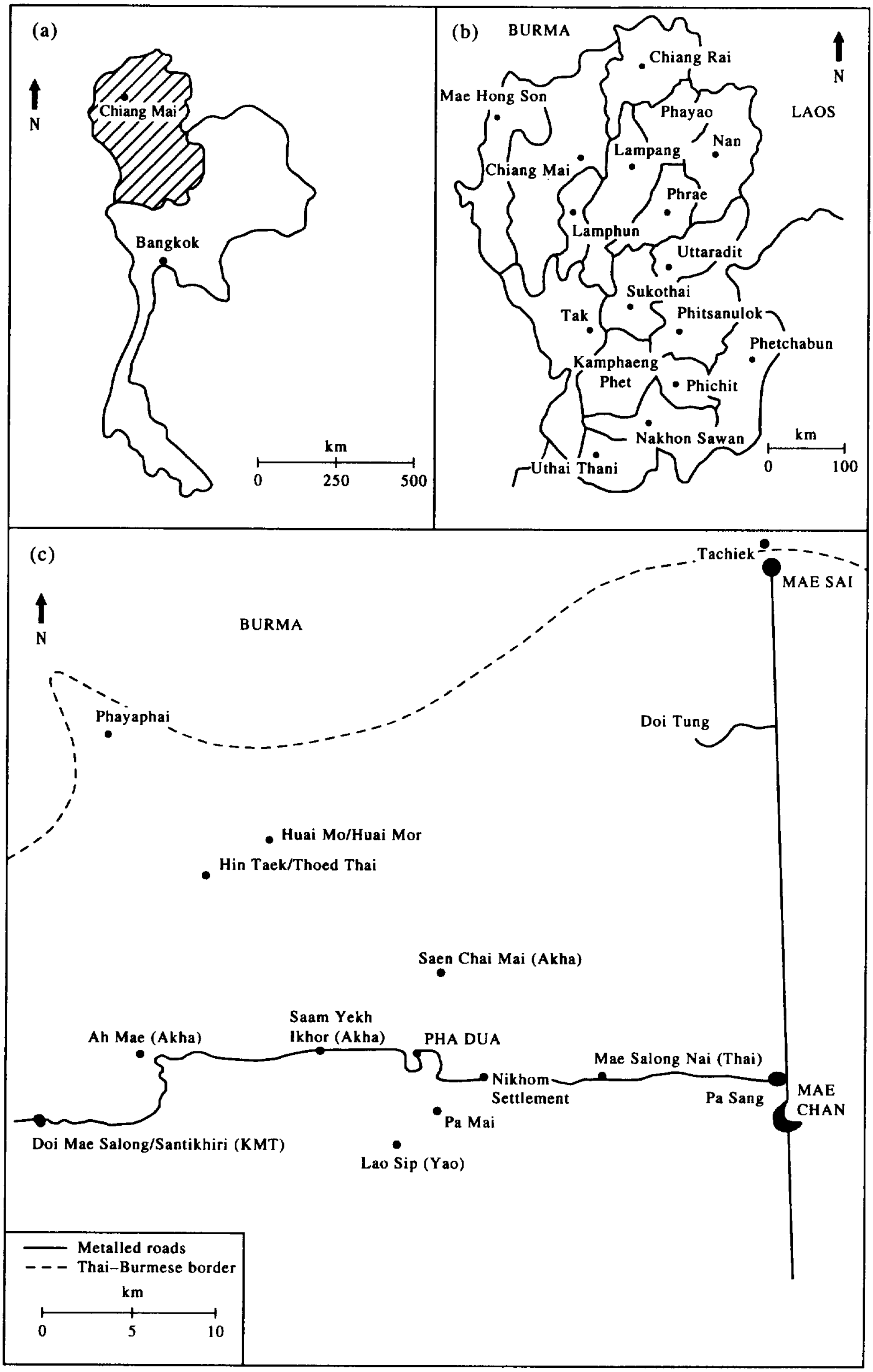

Figure 1. Location of research (a) Thailand (b) northern Thailand and (c) northern Chiang Rai province.

sedimentation as commonly thought (e.g. Trimble, 1983; Hatch, 1983; Nortcliffe and Dias, 1988; Douglas *et al.*, 1993). In northern Thailand, in the only study undertaken of long-term water supply records, Alford (1992) concluded that swidden agriculture had not impacted on long-term aridity, and that water shortages were more likely to be the result of increasing irrigation on the lowlands. Sheng (1979) tentatively estimated that 30% of lowland sedimentation in northern Thailand resulted from road construction.

Such 'myths' have also been claimed to relate to scientific assumptions about erosion and slope steepness (Hastings *et al.*, 1991, p. 67). Following the 1985 National Forest Policy Statement, all land in Thailand of slope steepness 35% or more was officially declared government-owned as a way to protect against erosion. However, this rule has apparently led to the assumption that most mountainous areas are all of this steepness. In the northern provinces of Chiang Mai and Chiang Rai, respectively 78 and 56% of so-called 'Detailed reconnaissance soil maps' constructed by the Department of Land Development are classified simply as 'hill-slope complex' because, apparently, they are steeper than 35% slope, yet field and GIS testing of this assertion has revealed up to a 50% error (Hastings *et al.*, 1991, p. 74; Pandee and Maathuis, 1990).

There is therefore much evidence to suggest that scientific assumptions about environmental degradation in northern Thailand are beset with 'myths' and 'falsehoods' that may be influenced by wider political concerns. However, indigenous knowledge of hill farmers may be no more accurate because it was developed in a time when shifting cultivation had sufficient time and space to be sustainable, which is no longer the case, and because such farmers have no knowledge of downstream impacts of agriculture. A hybrid study may therefore enable the testing of assumptions about environmental degradation.

The Case of Pha Dua

Research aims and site selection

The study aimed to test assumptions associated with Himalayan environmental degradation by using hybrid techniques. The study was divided into three stages of analysis: an initial mapping of slope steepness and land use; physical tests of environmental degradation and qualitative analysis of farmers' perceptions of degradation.

In order for the study to be typical of trends in general, much research was undertaken to identify a village that could be used for both extensive physical and anthropological work. A reconnaissance survey was undertaken, and advice sought from local extension workers and anthropologists to find a site in a mountainous area, inhabited by ex-pioneer shifting cultivators who were experiencing long-term problems of declining soil fertility for the first time. The site had also to be close to lowland communities, and in a zone where deforestation was considered to be a problem.

The site chosen was Pha Dua, a Yao village in the Mae Chan (now King Amphoe Mae Fah Luang) district of Chiang Rai province. Chiang Rai is Thailand's most northern province, and is generally considered to be highly deforested as the result of logging and immigration of shifting cultivators during the last century. In response to deforestation, and perceived security problems near the Burmese border, government policies have attempted to reforest mountain slopes or relocate villages. Pha Dua was founded in 1947. The Yao (Iu Mien) ethnic group originally came from central China and Laos. Historically, they are considered to be pioneer shifting cultivators and before coming to Thailand no villager at Pha Dua had lived longer at one site than 10 or 20 years. However, at Pha Dua, the Yao had effectively become permanent settlers, and were consequently experiencing long-term problems of declining soil fertility for the first time. The Yao are commonly described as hardworking and aggressive traders, yet with spirituality and customs reflecting their relationship with nature (Kandre, 1967, 1991; Miles, 1972; Hu Qiwang, 1991).

The village was located at altitude of about 650 m largely on granite and steeply rising quartzite and sandstone slopes that rose some 300 m from the valley floor. The main cultivation systems were non-irrigated hill rice, maize and soya on unterraced slopes although an increasing number were developing irrigated rice terraces in the valley bottoms. Originally composed of 10 households (about 110 people), Pha Dua in 1995 measured 118 households and approximately 900 people. Research in the village was mainly conducted in 1990–1992, although subsequent trips were made 1993–1995. See Forsyth

(1992, 1994) for further details of techniques adopted.

Land classification

Land classification aimed to assess if agriculture had moved onto steeper slopes during the history of the village. This was achieved by using maps made from aerial photographs. Historic photographs were fortunately available for the years 1954, 1969, 1977, 1983 and 1987, and allowed the mapping of land use approximately since the establishment of the village in 1947. Furthermore, the use of maps was considered more accurate than conducting field surveys and questioning farmers about historic patterns of agriculture. Maps were drawn with the use of a stereoscope and parallax bar, and supplemented by a map of 1991 land use constructed from field survey.

The aerial photographs varied in scale between 1:15,000 and 1:50,000. Consequently, only those features observable from the 1:50,000 scale series were used to create the maps. The clearest of the 1:15,000 series was used to make a topographic base map with contour intervals of 10 m for a research area of approximately 12 km^2 around the village. Discussions with villagers confirmed that this map covered about 80% of land used by villagers, and so it was deemed representative.

ArcInfo GIS was used as the means of spatial analysis. Previous work in northern Thailand has used GIS to great effect in land use and slope mapping (e.g. Hastings *et al.*, 1990; Pandee and Maathuis, 1990), and in Nepal similar studies had classified slope without the use of GIS (Bhan, 1988). However, to date, no previous research in the context of Himalayan degradation had used GIS to test the assumption that agriculture had moved onto steeper slopes as a consequence of land shortage.

Work was therefore undertaken to digitise the topographic map and land use maps, and to show how land use had changed over areas of steepest ground. The map of steepest ground was constructed by converting the topographic map into a TIN (Triangulated Irregular Network), and then converting this into slope angle. The topographic base map was used as the key reference, and all other maps were transformed to match these coordinates. A simple erosion model was then constructed using an index of erosivity from land use, and erosiveness from slope steepness. Land use on the maps were classified into four simple categories to indicate potential impact on erosion: bare soil (indicating current cultivation, and hence likely most erosive impact); to grass (indicating one or two years since cultivation); bamboo regrowth (indicating two to 10 years since cultivation); and closed forest (indicating at least 10 years since cultivation, and consequently least erosive impact). Such categories were acknowledged to be simple, but it was decided that these were the best accuracy available under the available photographic coverage, and during the cold-dry season, which is often used as a fallow period. It was also acknowledged that absorption of rainfall by bare ground may reduce erosion on bare soil compared with abandoned or grass land (e.g. Harden, 1993). However, it was decided to test the assumptions made in the model by statistical tests on physical measurements of erosion and soil degradation.

The historic incidence of these categories across the study area was used to indicate historic frequency of cultivation. The six land use maps were intersected to provide a cumulative index of cultivation since 1954, which could then be used to predict the erosivity of historic land use. This index was then intersected with the slope steepness map to show how the most frequent land use had coincided with the steepest slopes. Steepest land was considered to be most erodible, and slope categories were used ranging from 0–9.9%; 10–19.9%; 20–29.9%; 30–39.9% and 40% and over. The use of the percentage logarithmic scale for slope categories meant that the increase in shop inclination grew from the first category to the last, thus reflecting the increase of erosion risk with slope steepness (Zingg, 1940).

A final index of predicted erosion was created by multiplying the rank of the slope-steepness category with the rank of the historic frequency of land use category. Hence, a slope between 0–9.9% (rank 1) in the least-used category (rank 1) would score 1; yet a slope of over 40% (rank 5) in the most frequently used category (rank 4) would score 20. The range of this index was divided into four equal categories to indicate categories labeled "most eroded" (of index scores 16–20 inclusive) through to "least eroded" (scores 1–5). This index was then used to locate tests of physical degradation, and to test the assumption that agriculture had increased on the steepest slopes.

Physical tests of soil degradation and erosion

As stated in the discussion above, Himalayan environmental degradation refers to both upland and lowland degradation. However, the causes of each may be different. Upland soil degradation may be caused by erosion of topsoil or the exhaustion of nutrients by overcultivation. Lowland sedimentation, on the other hand, is only linked to upland erosion, but this erosion may be caused by agriculture or by naturally occurring geomorphological processes. Measurements of upland erosion may therefore be a useful indicator of both upland and lowland degradation. However, measuring erosion may not reveal all sources of degradation.

As also discussed earlier, previous models of erosion such as the USLE have been shown to be inapplicable to the humid tropics, or where indigenous communities may adapt to erosion. Erosion plots have been used extensively as mechanisms to measure current rates of erosion and runoff, yet these are highly time–space specific; require a great deal of management to infer rates effectively to the variety of land uses and slopes existing in upland villages; and are subject to tampering by locals in this highly populated region. Measuring visible truncation of soil profiles (Trimble, 1983) is also difficult in the tropics due to the typical deep depth of red soils after the removal of the surface horizons.

In addition, a distinction had to be made between measuring sheet and gully erosion. While both are likely to create declining soil fertility in uplands and sedimentation in lowlands, both require different measurement techniques (Evans, 1995). It was therefore decided to assess both sheet and gully erosion, although concentrating on sheet erosion as this was considered to be most likely to affect all farmers and their perceptions of declining soil fertility.

The Caesium-137 (^{137}Cs) method of measuring soil erosion was used to calculate historic sheet erosion on upland slopes. This method is growing in popularity as a way of accurately assessing historic rates and is achieved by comparing levels of ^{137}Cs deposited on soil in different areas after the thermonuclear bomb tests of the 1950s–1960s (Ritchie and McHenry, 1990; Walling and Quine, 1992). Input of the isotope peaked in 1963, and measurement is made by comparing the quantity of ^{137}Cs measured at sites deemed to have been disturbed since then, with other sites that may have experienced erosion or deposition. The benefit of this method is that it enables a relatively accurate measurement of erosion to be made for a known historic period. However, the disadvantage is that specialised equipment is necessary, and many samples are needed in order to reduce the standard error of measurement resulting from the variability of input of ^{137}Cs.

Samples of soil were collected from the 'most' and 'least' eroded sections of Pha Dua as indicated on the GIS map, and from two reference sites of flat, forested land (slightly outside the research area) which field survey and questioning of informants indicated were undisturbed since the 1950s. A 5 cm-width soil auger (which could be disassembled in order to preserve soil samples) was used to collect soil, and four cores were collected from the corners of a one-meter grid at each site in order to collect enough soil for measurement, and to reduce variability of ^{137}Cs between sites. Early testing showed that ^{137}Cs content declined beyond a soil depth of 25 cm, and incremental depth intervals of 5 cm were measured to collate the radioactive profile for each soil site. Eight samples from reference sites were collected, and six each from the 'most' and 'least' eroded zones. The differences between these were tested statistically with a *t*-test, although there was not sufficient time to collect enough samples from each zone to achieve a standard error of below 5%, as usually recommended (Forsyth, 1994, p. 234).

The equation for estimating erosion rates is shown below. This was adapted from previous work using ^{137}Cs, and assumed a linear relationship between isotope activity and soil loss, with an adaptation for a measured tilling depth of 15 cm. Erosion was dated to the significant regional peak in ^{137}Cs input of 1963.

$$SRD\ (\text{net}) = N\text{-}1963\sqrt{X/YR} \cdot H \cdot DD \cdot \frac{1 \cdot 10^8\ \text{cm}^2}{1 \cdot 10^6\ \text{g}}$$

where SRD (net) = net time integrated soil redistribution (t ha^{-1} yr^{-1})
X = measured ^{137}Cs in sample profile
YR = base level ^{137}Cs input measured in reference core
H = depth of plow layer (15 cm)
DD = dry density of soil (average of subsamples)
N = year of sampling (1991)

(after Sutherland and De Jong, 1990; Zhang Xinbao *et al.*, 1990).

In addition to this, gully erosion was assessed by mapping the distribution and nature of gullies, and by questioning informants about their age and importance. It was assumed that soils would be the same ultisols throughout the test area, although visual inspection and tests of soil texture and organic matter revealed that the steepest slopes had significantly less organic matter and significantly more clay content than flatter slopes. This was attributed to the erosion of the root zone on steep slopes. In general, soils in the area were several meters deep, as revealed by road cuttings, although on some steep slopes a high number of stones were encountered when removing soil samples, indicating close proximity to the bedrock.

Questioning and observation of farmers

The final part of research, accessing farmers' perceptions, is notoriously difficult in remote cultures, and where, as in northern Thailand, there has been a history of enquiry by outsiders into illegal activities such as drug production, unlicensed immigration or logging. Simple, structured questionnaires were unsuitable to these conditions because they rarely achieve accurate answers (Dixon and Leach, 1984). Questioning was therefore conducted over a period of months after the researcher had become fluent in Thai and well known to the community.

A variety of techniques was used to reduce dependency on one method alone. Most questioning was conducted with key informants who were selected for their knowledge of the village and of farming problems (Chambers, 1983; Chambers *et al.*, 1989). These included the high priest and previous villager leader, the current village leader; a woman noodle-shop owner and various male and female heads of households.

Information from these informants allowed the construction of a semi-structured questionnaire for 62 randomly-selected other households (out of approximately 110) on the nature of land use and perceptions of environmental degradation. These interviews were conducted in Yao language with the help of an interpreter into Thai. Discussions with farmers were supplemented by observation of farming techniques, particularly during the planting time at the start of the rainy season (May–June).

Results

Figure 2 shows the distribution of the index of predicted erosion between the four categories ranging from 'most eroded' to 'least eroded'. The index is heavily skewed to the left, showing that the majority of land is contained within the first three categories. In fact, just 2% of the research area is in the 'most eroded' category, compared with 26% in the 'least eroded' section. This therefore indicates that historic agriculture has tended to be on flatter, rather than steeper slopes. However, it needs to be made clear that the eroded categories are predictions based on a simple land use/slope steepness model.

The measurements of ^{137}Cs verified the division of land between the categories of 'most' and 'least' eroded. The statistical tests conducted between the reference samples and measurements taken in the two predicted categories were all found to be greater or smaller, to statistically significant levels of at least 95%. Using an equation that linked ^{137}Cs content to topsoil (Forsyth, 1994, p. 235), the historic soil-erosion rates for 1963–1991 were calculated of 24 t ha^{-1} yr^{-1} for the 'least eroded' zone (standard error 15%), and 64 t ha^{-1} yr^{-1} for the 'most eroded' area (standard error 11%). The standard error for the reference zone samples was 11%. Such erosion rates are broadly in line with rates on granite land measured elsewhere in northern Thailand (Tang-

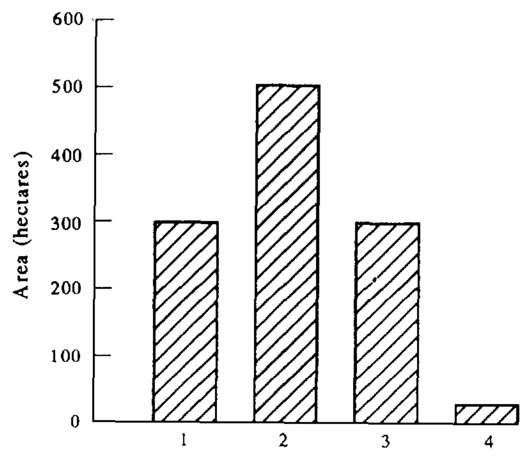

Figure 2. Relative areas of zones of predicted erosion (hectares). 1 = Least eroded, 2 = 3rd most eroded, 3 = 2nd most eroded, 4 = Most eroded. Source: ArcInfo GIS.

tham, 1991) and the world (e.g. Lal, 1993), although much higher than sheet erosion measured with plots under natural forest cover in Thailand.

Tests of soil degradation also revealed that the 'least eroded' zone had more organic matter and less clay than the 'most eroded' zone (again to statistically significant levels of 95%). This indicated that erosion had impacted badly on soil fertility by removing topsoil, and exposing the weathered 'C' horizon. The assessment of gully erosion indicated that gullying was extensive, and largely characteristic of the research area. Gullies may be defined in various ways (e.g. Stocking, 1980), but the majority of gullies observed at Pha Dua seemed similar to the *pahiro* gullies observed in Nepal by Smadja (1992, p. 7), and, as such are naturally occurring on granite land. This was supported by evidence from GIS concerning the frequency of different slope categories. Figure 3 shows the areas covered by slopes of different steepness, and there is a marked absence of slopes between 10 and 19.9% slope. This phenomena has been noted elsewhere in northern Thailand using 1:50,000 topographic maps (Hastings *et al.*, 1990, p. 73; Pandee and Maathuis, 1990), and it is possible this distribution may indicate a so-called 'all-slopes-topography' characteristic of granite encountered elsewhere in the world, such as in southeast Brazil (Twidale, 1982, pp. 177–183).

Villagers questioned about these gullies confirmed that they had existed before the establishment of the village, and that they also could be found in forested areas (confirmed by field survey). However, villagers

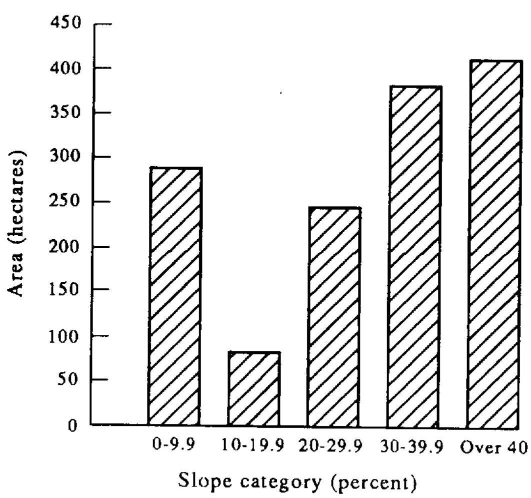

Figure 3. Relative areas of different slope categories (hectares). Source: ArcInfo GIS.

also explained that some of the more incisive gullies had been caused by road construction in Pha Dua in the early 1970s and 1980s. Indeed, in 1995, the deepest gully (not *pahiro*) threatened to undercut the main road to the village. However, research in the Indian Himalaya has indicated that gully erosion may be lessened by deforestation because incision is stopped by aggradation of eroded soil (Froehlich and Starkel, 1993). Research in Pha Dua did not measure sediment yield from gullies, but observation noted that gullies were generally densely vegetated and consequently likely to act as sediment traps. Because of this, it was unlikely that erosion from agriculture could cause soil to move overland directly into gullies and then be transported to the lowlands, although further research would be required to test this relationship.

Discussions with villagers confirmed that they saw steep slopes as more erodible and hence as hazardous to agriculture. Most farmers avoided using these slopes, and those that did could only cultivate crops there for a limited time of one or two years before yields declined significantly. The majority of farmers questioned, however, did not use the steepest slopes, and so complained more of declining agricultural productivity and shortage of land as problems, rather than erosion.

The communication of concepts relating to environmental degradation proved to be difficult. The common Thai expression for soil erosion (*kaan phangthalay khong din*) literally means "the falling down of soil", and so was initially confused with 'landslides' which villagers denied happened at Pha Dua. Discussion with informants and interpreters managed to define the word further, thus enabling local knowledge about erosion to emerge.

Similar problems occurred with the concept of 'productivity' which was often confused with 'total production'. Yet this misunderstanding typified much of the discussions about soil fertility. While observations showed the Yao to be diligent farmers, the immediate concern of farmers was not about the long-term productivity of soil, but instead the shortage of land, and the ability to maximise economic production. Soil-conservation measures used included fallow, crop rotation, and adding ash from grass and bamboo burnt before the planting season in May–June. However, virtually all farmers resisted attempts by local extension workers to introduce vertiver-grass strips because they were seen as a waste of space and labour. Farmers also adopted chemical fertiliser and pesticide as short-term measures against declining productivity.

Land shortage, rather than soil degradation, was claimed to be the major problem of farmers. This was confirmed by trends in the use of fallow. In the 1960s, informants claimed each household used fallow periods of between 7 and 10 years per plot. In 1991, this period had fallen to an average 3.5 years (based on the 62 households questioned). Only 39% of those questioned used fallow, and this was for just 20% of land owned each year. When discussing soil fertility itself, 48% of farmers used language to suggest they had 'serious' problems of declining productivity; 21% had 'mild' problems; and 34% claimed to have none (Forsyth, 1992; 1994, p. 239).

The problem of land shortage was supported by evidence from the land-use maps (see Table 1). Closed forest declined rapidly between 1954 and 1969, indicating the influx of shifting cultivators during that period. However, since 1969, closed forest has increased in area, showing a reduction in average farm area available to each household in the village. Villages explained that this was the result of a new system of land ownership which developed during the early 1970s by which households laid claim to specific plots of land, and used these each year, rather than the historic rotational, or shared land ownership system. This change was due to the important decision of villagers at that time to see Pha Dua as a permanent settlement rather than a site to be left after 10–20 years.

Table 1. Areas of historic cold–dry season land uses at Pha Dua

(Hectares)*	1954†	1969	1977	1991
Closed forest‡	440.5	78.6	212.6	216.6
Bamboo regrowth	652.9	19.5	705.9	332.7
Grass	120.6	1130.9	146.5	587.6
Bare soil	82.0	53.8	73.1	10.9
Rice terraces§	—	—	25.5	8.9
RFD land¶	—	—	125.3	131.0
Settlement	2.4	5.2	9.5	10.7

*Historic aerial photographs from 1983 and 1987 were used for mapping but covered respectively only 75% and 76% of the study area defined by the topographic map, and so were excluded from the table.
†Pha Dua established in 1947.
‡Closed forest, bamboo regrowth, grass, and bare soil were the only categories used to construct the index of historic frequency of cultivation. Closed forest was taken to indicate an absence of cultivation for 10 or more years; bamboo for 2–10 years; grass for 1–2 years; and bare soil indicating current cultivation. It is acknowledged that these figures do not indicate internal forest quality (Savage, 1994).
§Rice terraces were said to be increasing by informants, and so the low 1991 figure is probably a mapping error resulting from the misinterpretation of grass during field survey.
¶Royal Forestry Department reafforested land, established early 1970s.
Sources: 1954, 1969: 1:50,000 aerial photographs.
1977: 1:15,000 aerial photographs.
1991: field survey (January).
All photographs dated January except 1969 (February) and 1983 (November).

Villagers explained that the decision to make Pha Dua a permanent settlement resulted from the realisation that suitable land for a new settlement was unavailable elsewhere. In addition, the decision of the government to build a road through the village had brought economic advantages to the village, and had established it as a local trading centre. However, villagers had already experienced land shortage at Pha Dua after the Royal Forestry Department (RFD) had established a teak plantation on land used by Pha Dua, and after the arrival of new migrants to the village who had claimed land already used by existing inhabitants. This resulted in the new system of land claimed by separate households, and connected to this, households felt the need to utilise land each year as a way to indicate ownership.

This development was also accompanied by a voluntary decision of the village to leave a steep, forested section above the village as a village woodlot. This decision was made because the village needed forest products, and because the slopes were considered to be too steep for agriculture. Interestingly, this decision was apparently not an attempt to preserve a water supply to the village. When asked (in 1995) if cutting trees increased or decreased water supply, two elderly informants in the village laughed and said that it was a long standing truth among the Yao people that cutting down large trees actually increased water supply, and made it available throughout the year. They claimed that it was only since coming to Thailand from Laos that they had heard people suggest anything different, and that these were lowland Thais or extension workers.

Discussion

The results of the case study provide much information which can be used to falsify assumptions about Himalayan degradation, as well as draw conclusions on the value of hybridity and indigenous knowledge. The apparent fact that the upland farmers see land shortage as a greater problem than erosion, resist new soil-conservation measures, or consider deforestation as a means to increase water supply suggest that they do not conform with the assumptions made about environmental processes made by groups outside their area. This may indicate that their indigenous knowledge is closer to truth than our own 'myths' ('falsehoods'), or that we can brand them as having 'myths' of their own.

However, in this case study, there is plenty of additional evidence to suggest alternative reasons for erosion not perceived as a degrading environmental process. Most obviously, this is the fact that farmers perceive erosion to be damaging to agriculture, and hence they avoid it by cultivating flatter slopes rather than steeper slopes. This ends a myth about hill farmers (in at least northern Thailand) that they do not care about the erosion they produce: they are well aware of it, and consequently avoid it rather than ignore it.

The GIS index of predicted erosion (Figure 2) is—in this location—striking evidence that the assumption in the quotations of Eckholm (1976, p. 77) and Ives (1980, p. 10), that land shortage is leading to increased cultivation of steeper slopes, is misplaced. Instead, hill farmers are using flatter land more frequently. As a consequence, soil fertility is declining more by the exhaustion of nutrients during overcultivation, rather than by the removal of nutrients by erosion. Such a trend has been observed elsewhere (Sillitoe, 1993; Thapa and Weber, 1995).

Also, the assessment of gully erosion suggested that much lowland sedimentation is of natural origin, or even arising from road construction. The case study has no data to indicate what proportion of sedimentation arises from these gullies, or of how agriculture may increase or decrease their impact. However, the existence of these gullies, and the perception of erosion as something to be avoided by upland farmers, indicates that upland agriculture may be overrated as a source of lowland sedimentation in Thailand. This is also supported by Trimble's classic work (1983) showing that much sheet erosion was stored on lower slopes rather than transported out of a basin in rivers.

Consulting indigenous knowledge has therefore helped test wider assumptions about environmental degradation at a small scale, and present evidence that these assumptions may be misplaced. However, it is important, as Murdoch and Clark (1994, p. 125) warn, not to romanticise local knowledge, as indeed it may have its own element of 'mythology' as a result of being developed for specific time and space scales. In Pha Dua, the experience (to date) of soil erosion rates of between 28 and 64 t ha^{-1} yr^{-1} (1963–1991) has clearly led (at least in the 'most-eroded' zone) to the removal of fertile topsoil, and is also likely in some extent to contribute to lowland sedimentation. Deforestation at a larger scale, may also indeed cause biodiversity and hydrological impacts, contrary to local knowledge. Consultation of indigenous knowledge has therefore helped test outsiders' perceptions at a local scale, but is this to assign it with greater status than those assumptions, or should the indigenous knowledge itself be tested?

To some extent, the case study employed techniques which allowed the verification of local perceptions. The GIS index of predicted erosion and physical tests of soil degradation allowed independent confirmation of villagers' statements. However, the study was structured to test outsiders' statements rather than villagers'. Plus, the nature of their perceptions was not known before the start of the study. Hence, using indigenous knowledge in tests of assumptions held by outsiders is partly an ideological choice, because it proposes that western, or scientific, knowledge may be wrong, and that indigenous knowledge (assuming it is collected in an objective and considered way) is right. However, the increasing adoption of indigenous knowledge as a source of accurate information reflects the increasing choice of the environmental scientific community rather than the imposition of a new ideology from non-scientists (Popper, 1994, p. 22), and therefore represents an increase in power attributed to indigenous knowledge compared with the previous 'white mythologies' (Young, 1990).

The result of such hybrid studies is therefore an increased respect for local communities as experts, if not always their knowledge as accurate beyond their experience (a conclusion urged by Agrawal (1995) and Jewitt (1995)). In northern Thailand, research has indicated that the Yao minority are adaptable and sensible regarding the potential erosive impact of agriculture on steep slopes. Yet they are understandably (so far) unaware of the impacts of over frequent cultivation or potential downstream impacts. Similarly, the lowland Thais are rightly concerned over the loss of biodiversity in upland forests, yet have apparently overstated the role of outsiders in impacting on resources rather than their own impact as consumers of water (Thailand is the world's largest exporter of rice), or the role of increasing perception of environmental degradation (either by increasing population density on the borders of the mountains, or by a general increase in environmental concern resulting from education and the rise of the middle class: Redclift and Woodgate (1994).

The overstated concern about damage to resources—be they forest and water, or aesthetic and recreational—rather than an analysis of how this fear is constructed, is what led to the overstatement of environmental crisis by the original Himalayan environmental degradation theory during the anti-modernisation movement in western countries in the 1970s. Such projections of a crisis may still exist in science's apparent continued belief in erosion as a hazard, possibly because of the economic and social impact of the Dust Bowl in the 1930s, and consequently on the preferred consideration of sheet and accelerated erosion above gullying, or natural causes of erosion. While some erosion is undoubtedly environmentally degrading, knowledge of it, as illustrated in this case, leads to it being avoided. Results like these suggest that reflexivity is a necessary condition of making wide-reaching statements about environmental degradation, especially when resources are seen to be threatened.

This study has tested some assumptions, or 'myths' of the scientific community regarding environmental degradation in one location, and has resulted in evidence that may be used to falsify them. Arguably, this has done little in managing environment except to show how these assumptions may be wrong. Perhaps a more constructive route, and one that attributes more power to local communities, is to use local knowledge as the starting point in research, and to use western science as the means to extend these to wider areas for management. In Thailand, results of this study suggest that government policies aiming to reduce sedimentation and water shortages by reforestation and resettlement may not achieve these environmental goals, and may instead be reflective of traditional state concerns to gain control over remote land and minorities.

However, before wider management can take place, there is a need to define more closely the concepts of 'myths' and 'falsehoods' (Metz, 1989; Thompson, 1989) between the locally-based knowledge of communities; politically-constructed assumptions about the environmental impacts of other communities; and the falsifiable assertions of science in an attempt to develop management techniques. This is not to suggest that science can somehow escape reflecting social and political trends, but instead that a concern by scientists to incorporate different viewpoints might make more effective and equitable management (Redclift and Woodgate, 1994).

Conclusions

This paper has described 'hybrid' research techniques used to test Himalayan environmental degradation theory in northern Thailand. A typical village of historic 'pioneer' shifting cultivators was selected in the uplands, and the assumptions that land shortage had increased agriculture on steep slopes, and that erosion presented a major problem to farmers, were tested using indigenous knowledge, GIS and the Caesium-137 technique of measuring soil erosion.

The results of the study indicated that, contrary to common perceptions, upland farmers are aware of the risk posed by erosion, and consequently avoid cultivating steep slopes. Land shortage has therefore increased the frequency of cultivation on flat slopes, rather than increased cultivation on steep slopes. As a consequence, declining soil fertility is more likely the result of exhaustion of nutrients through overcultivation, rather than the removal of nutrients by erosion. Furthermore, the existence of local, naturally-occurring gullies suggested that much erosion and lowland sedimentation existed before the establishment of upland farming.

The results support findings from elsewhere in Asia which suggest that lowland assumptions about the environmental impacts of upland agriculture may in fact reflect lowland fears about resource degradation, and long-term political conflicts between upland and lowland communities. In Thailand, the results suggest that government environmental policy should seek to restore soil fertility in the uplands through nutrient fixation rather than erosion control. In addition, they suggest that policies should seek to reduce water shortages and sedimentation problems on the lowlands by reducing water consumption, and avoiding natural sedimentation rather than attempt to control these by reforestation and resettlement of upland villages.

This hybrid study has therefore indicated the adaptability of local communities and the folly of some western assumptions. However, it did this by testing western assumptions, rather than local knowledge. The study also questioned the applicability of local knowledge concerning deforestation or biodiversity over wider areas, rather than naively accepting it as truth. The power balance of environmental research has moved towards the communities but not their knowledge. Through this, it is hoped that the use of indigenous knowledge in scientific enquiry may not increase the marginalisation of minorities (Agrawal, 1995), but instead heighten their status in environmental and developmental policy.

Further hybrid studies may attempt to test the assumptions made by local knowledge, rather than those imposed by others. However, the purpose of testing will be clearer when researchers agree on the difference between 'myths' and 'falsehoods', and differentiate between locally or culturally-based knowledge about environment; politically or socially-constructed fears about the impact of other groups; and falsifiable scientific statements aiming to develop practical environmental management.

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