BREAKING DOWN THE POVERTY-ENVIRONMENT RELATIONSHIP IN PAPUA NEW GUINEA

"It's the same the whole world over,
It's the poor what gets the blame,
It's the rich what gets the pleasure,
Isn't it a blooming shame?"

CONCEPTUAL FRAMEWORK

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THE POVERTY-ENVIRONMENT RELATIONSHIP IN PUBLIC POLICY

The Medium-Term Development Strategy and the Millennium Development Goals

The PNG Government's 'Medium-Term Development Strategy' has quite a lot to say about the alleviation of human poverty, a lot less to say about protection of the natural environment, and nothing at all to say about the poverty-environment relationship, except insofar as it contains a table setting out the national targets and indicators for the Millennium Development Goals (MDGs). Despite a passing recognition of the country's 'clean, natural environment' as something which lends it a comparative advantage in the 'global market' for environmental goods (PNGDNPRD 2004: 13), the fourth of the 'Ten Guiding Principles' aims to 'maximise the value of our natural resources and environment, through sustainable primary production and downstream processing, with a focus on agriculture, forestry, fisheries and tourism supported by mining, petroleum and gas' (ibid.: i). The MTDS also declares that 'absolute poverty is not a widespread problem', even if 'a significant proportion of the population is affected by relative or human poverty, as reflected by very low cash incomes, poor economic opportunities, and poor health and education standards' (ibid.: 25).

The MTDS does not pretend to be a comprehensive statement of the Government's approach to the MDGs, because that is something reserved for the National Poverty Reduction Strategy which has not yet been finalised (ibid.: 26). However, a comparison of the proposed national targets and indicators with the global targets and indicators proposed by the United Nations or the World Bank does provide some interesting clues about the Government's understanding of the poverty-environment relationship. If we adopt the multi-dimensional view of human poverty that informs the UN Human Development Reports, then all eight of the MDGs can be seen as part of a single poverty reduction strategy, but for the purpose of the present study, we shall focus attention on the the first and the seventh of these goals.

If the Government is right to say that 'absolute poverty is not a widespread problem' in PNG, then it might also want to deny that PNG has much if any of the 'extreme poverty and hunger' whose eradication constitutes the first MDG. The first 'Global Target' for achievement of this goal is to halve the proportion of people living on incomes of less than one US dollar (currently about three PNG kina) a day, and there is no doubt that a significant proportion of PNG's population does not earn this amount of money. However, PNG also has a thriving subsistence economy which supplies many of the daily needs of its population, and enables some people to argue that national poverty is an artefact of the foreign imagination. For example, the author of one recent letter to the editor of a national newspaper called on foreign experts to acknowledge a number of home truths:

- about 80 per cent of the population live on K0.00 a day, yet they go to bed each night with full stomachs;
- only those who are too lazy to plant, fish or hunt go hungry;
- the vegies, fish and fruits that the rural 80 per cent consume each day, if measured in cash, are worth more than K3 a day;

- the agricultural, marine and other natural products that all Papua New Guineans have access to, if the learned doctor could put a cash value on, will be more than K3/day; and
- nearly all of the rural 80 per cent are happy and are content with life in the villages, even though they have zero balance or no accounts in a bank (*Post-Courier*, 23 December 2004).

Although the World Bank and the United Nations do adopt the 'dollar-a-day' poverty line to measure the global distribution of poverty, the poverty line mentioned in PNG's version of the first Global Target (see Table 1) is derived from a World Bank-funded Poverty Assessment that did try to measure the value of subsistence food production, and still found a significant proportion of people living in poverty, especially in rural areas (Gibson and Rozelle 1998). In the absence of any equivalent survey data since 1996, and regardless of the way that the 'poverty line' is actually calculated, the World Bank estimates that 'poverty levels have increased alarmingly in recent years, and are unlikely to climb down in the immediate future' (World Bank 2004a: 3). What this means, in very simple terms, is that half people currently defined as 'poor' by one measure or another would have to double the value of their consumption over the course of the next decade in order for PNG to reach its first 'National Target'. However, the MTDS does not include any commitment to repeat the previous survey in order to find out whether this target has been achieved.

Table 1: Global and national targets for the first Millennium Development Goal (to 'Eradicate Extreme Poverty and Hunger').

Global Target 1: Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day.	**National Target 1**: Decrease the proportion of people below the poverty line by 10 per cent by 2015, using the 1996 national average figure of 30 per cent below the *lower* poverty line as the benchmark figure.
Global Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger.	**National Target 2**: By 2015, increase by 10 per cent the total amount of agriculture commercially produced and by 34 per cent the amount of subsistence agriculture production.

Although the 1996 Poverty Assessment based its definitions of 'poverty' on the value of local food consumption, the MTDS does not seem to regard this kind of survey as a way of measuring progress towards the second Global Target, which is concerned with the eradication of hunger. Instead, it proposes to address the problem of hunger by raising the volume of agricultural production, especially within the subsistence sector (see Table 1). It is not clear why the second National Target is aiming for a 10 percent increase in the commercial sector, and a 34 percent increase in the subsistence sector, nor is it clearly stated that these are meant to be changes relative to population growth, and therefore changes in the level of agricultural productivity. However, if that is what is meant, then it would seem that the PNG government is aiming to eliminate hunger by boosting the productivity of the subsistence sector relative to the commercial sector, at a time when the national market for domestic food crops has been expanding very rapidly (Bourke 2005). This does not make a great deal of sense, whichever way we look at it, and so we might perhaps infer that 'commercial agriculture' here means 'production of cash crops for export', while 'subsistence agriculture' here means 'production of food for local consumption', whether or not it passes through a local market.

We might expect that this question would be resolved by the selection of indicators to measure agricultural output or productivity, but that is not the case. All of the proposed indicators are measures of malnutrition, of the kind that were applied in PNG's National Nutrition Survey of 1982-3 (Heywood et al. 1988), and are likely to be applied again the new survey scheduled for 2005. Two of these national indicators are the two recommended by the United Nations as measures of progress towards the second Global Target, namely the prevalence of underweight children under five years of age and the proportion of the population below the 'minimum level of dietary energy consumption'. The UN Food and Agriculture Organisation estimates that 14 percent of PNG's population currently fall below the standard set by the second of these indicators, which is somewhat lower than the estimate of 17 percent made by the 1996 Poverty Assessment. These figures would suggest that PNG is faring much better than most of the countries in sub-Saharan Africa (see http://millenniumindicators.un.org/unsd/mi/mi_goals.asp), but if we are led to believe that the incidence of malnutrition has been declining with the growth of domestic food production, we must then wonder why the World Bank believes that 'poverty levels' have been increasing at the same time.

The Government's belief that PNG still has a 'clean, natural environment' may explain why the need to 'reverse the loss of environmental resources' has not been recognised in the national equivalent of Global Target 9, which is the first of three Global Targets for the seventh MDG (see Table 2). On the other hand, it might have something to do with the addition of a National Target which has no obvious global equivalent, but is still presented as a way of 'ensuring environmental sustainability'. Insofar as National Target 13 aims to 'increase commercial use of land and natural resources', it seems to reflect the fourth of the 'Ten Guiding Principles' in the MTDS, which aims to 'maximise the value of our natural resources and environment' through 'sustainable' forms of primary industry.

Table 2: Global and national targets for the seventh Millennium Development Goal (to 'Ensure Environmental Sustainability').

Global Target 9: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources.	**National Target 12**: Implement the principles of sustainable development through sector specific programs by 2010 and no later than 2015.
	National Target 13: By 2020, increase commercial use of land and natural resources through improvements in environmentally friendly technologies and methods of production.
Global Target 10: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and sanitation.	**National Target 14**: Increase to 60 per cent the number of households with access to safe water by 2010 and to at least 85 per cent by 2020.
Global Target 11: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers.	**National Target 15**: By 2020, to have achieved a significant improvement in the lives of disadvantaged and vulnerable groups in urban areas.

While the indicators proposed for National Target 12 generally match those which the United Nations recommends for Global Target 9, the Government has chosen to convert a single indicator for the 'proportion of land area covered by forest' to a set of three indicators:

40. Percentage of land area covered by primary forest
41. Primary forest depletion rate (percentage) per year
42. Re-forestation rate (percentage) per year

Now one might suppose that Indicator 41 is a rather badly phrased version of Indicator 40, because the rate of 'primary forest depletion' is surely the rate at which the 'land area covered by primary forest' is actually being reduced. But the consistency of the Government's thinking on this question is called into question by the first four indicators proposed for National Target 13:

48. Percentage of land used for commercial purposes
49. Percentage of cultivable land used for agricultural production
50. Agricultural exports as a percentage of all exports
51. Value of agricultural exports as a per cent of total GDP

Presumably, some of the land which could be used for agricultural production or 'commercial purposes' is currently covered by 'primary forest', especially if the 'commercial purposes' include forestry operations. So perhaps the Government really does see forest conversion as a way of achieving 'environmentally sustainable development' provided that it is undertaken by means of commercial operations which use 'environmentally friendly technologies and methods of production'.

One way to interpret the indicators listed for National Target 13 is to think of them as indicators that really ought to apply to National Target 2, which was indeed about the expansion of agricultural production, rather than the national equivalent of Global Target 9, which is about the conservation of 'environmental resources'. But if this is evidence of slipshod bureaucratic thinking, it still leaves the impression of a muddle in the Government's thinking about the relationship between primary industry, environmental protection, and poverty alleviation. The underlying message seems to be that more agriculture of one kind or another is a good thing for the natural environment, as well as for the wellbeing of the national population, even if it involves a certain amount of forest conversion. And if we ask why the Government takes this view, the most plausible answer would be that agriculture causes less environmental damage and social disruption than the extractive industries which currently dominate the formal economy, so the promotion of agricultural development will sooner or later compensate for an unsustainable condition of resource dependency. Although this message is not made explicit in the MTDS, it is certainly a view that is shared by many officials in the central agencies of the PNG Government and in the foreign aid agencies that bring their influence to bear on the country's development strategies (Baxter 2001).

The extent of PNG's dependency on the exploitation of natural resources, and its vulnerability to the so-called 'resource curse' (Sachs and Warner 2001), is normally illustrated by the composition of the country's export revenues. In this respect, the national economy has barely changed its shape in the course of the last 15 years. The extraction of non-renewable mineral resources continues to account for roughly three quarters of the country's export revenues, while the share derived from agricultural production has mainly varied because of an unsustainable log export boom in the 1990s (see Table 3). Even if the agricultural share grows larger over the course of the next decade, this may only reflect the fact that the logging, mining and oil industries are running out of resources.

Table 3: Sectoral contributions to PNG's domestic export revenues, 1990-2004.

YEAR	MINING & OIL	AGRICULTURE	FORESTRY	MARINE
1990	72.1%	19.5%	7.6%	0.8%
1995	71.6%	14.8%	13.2%	0.4%
2000	77.4%	16.6%	5.4%	0.6%
2004	73.3%	20.8%	5.3%	0.7%

Source: Bank of Papua New Guinea.

Insofar as the PNG Government has articulated an official policy position on the poverty-environment relationship, this seems to be built on four basic assumptions:

1. *PNG is a country rich in natural resources, and if these resources were to be used in the right way, then none of its people would be poor by any standard.*
2. *Whatever damage has been done to PNG's natural environment has been caused by greedy foreigners, and not by Papua New Guineans, rich or poor.*
3. *The environmental damage caused by greedy foreigners has brought some economic benefits to PNG, but only to a small minority of its people, leaving the rest in relatively greater poverty.*
4. *PNG is essentially a nation of gardeners or farmers, so further agricultural development is the only way to raise the standard of living of the vast rural majority without causing further damage to the natural environment or selling more of the nation's wealth to greedy foreigners.*

As we shall now see, this set of assumptions is rather different from the one that has informed much of the global debate about the poverty-environment relationship.

Unwinding the Downward Spiral: Reflections on the Brundtland Report

The downward spiralling poverty trap was part of the vision of sustainable development put forward in the report of the World Commission on Environment and Development, otherwise known as the Brundtland Report:

> Many parts of the world are caught in a vicious downwards spiral: poor people are forced to overuse environmental resources to survive from day to day, and their impoverishment of their environment further impoverishes them, making their survival ever more difficult and uncertain (WCED 1987: 27).

This representation of the downward spiral drew on earlier 'crisis narratives' (e.g. Myrdal 1963; Eckholm 1976) whose portrait of the link between poverty, population and environmental degradation can be traced back to the gloomy prophecies of Thomas Malthus. Empirical evidence of the operation of this vicious circle was assembled in a number of publications over the course of the decade following publication of the Brundtland Report (e.g. Durning 1989; Mink 1993; Pearce and Warford 1993; Cleaver and Schreiber 1994; Dasgupta and Mäler 1994). In the year of the Rio Earth Summit, it also made a famous appearance in the pages of the World Bank's World Development Report on 'Development and the Environment':

> Land-hungry farmers resort to cultivating unsuitable areas – steeply sloped, erosion-prone hillsides; semiarid land where soil degradation is rapid; and tropical forests where crop yields on cleared fields drop sharply after just a few years (World Bank 1992: 30).

The Brundtland Report allowed that the downward spiral was itself the effect of 'many present development trends' (WCED 1987: 254), but by failing to identify these trends, it failed to allocate any blame beyond the agency or responsibility of poor people themselves (Hayes 2001). The image of the downward spiral appealed to the governments of the South because it suggested that they could keep their environmental cake while eating it for the purpose of 'development', or in other words, that they would not have to sacrifice their prospects of economic growth in order to conserve Southern environmental values for the benefit of Northern consumers. At the same time, the image appealed to the governments of the North because it allowed them to believe that the affluence of their own citizens had a positive environmental impact (Chatterjee and Finger 1994). The consensus established at the Rio Earth Summit was therefore one which facilitated a whole new raft of global funding for 'integrated conservation and development projects' that were meant to reverse the downward spiral in those Southern locations where poor people were supposedly threatening precious environmental values.

It is no longer possible to say that the downward spiral represents the orthodox or dominant understanding of the poverty-environment relationship, even amongst the multilateral institutions which endorsed it 15 years ago. Even at the time of the Rio Earth Summit, the World Bank had a second model of the poverty-environment relationship, which is known as the 'environmental Kuznets curve'. According to this model, environmental degradation is primarily a feature of the early stages of industrialisation, which means that the people or nations responsible should be described as those with relatively low but rapidly rising incomes, rather than those who are simply 'poor' (World Bank 1992; Grossman and Krueger 1995). Needless to say, this perspective does not seem so appealing to the governments of rapidly developing countries, but it is not by any means the only basis on which the downward spiral has been called into question. A review of the literature on this subject suggests that it is only the first of at least twelve counter-arguments:

- There are many kinds of environmental degradation which are the direct effect of actions by rich and powerful people or countries (Duraiappah 1998; Tucker 2000), and these actions include the 'export' of environmentally degrading activities from wealthy countries or regions to poor countries or regions (Redclift and Sage 1998).
- It is often the wealthier members of relatively poor rural communities whose actions make a bigger contribution to the process of environmental degradation than those of the poorer members (Cavendish 2000; Gray and Moseley 2005).
- Even if poor populations grow faster than wealthier populations, they may also respond to the resulting environmental pressures or scarcities by changing their production systems in ways that prevent further environmental degradation (Richards 1985; Turner et al. 1993; Tiffen et al. 1994; Fairhead and Leach 1996).

- While poor people are often more vulnerable to environmental degradation than other people because of their greater dependence on natural resources (Reddy and Chakravarty 1999; Cavendish 2000), environmental degradation may sometimes be good for poor people if they are able to use the income gained from depleting their resource base to improve their livelihoods in other ways (Shyamsundar 2002).
- Definitions or perceptions of 'environmental degradation' may in any case be based on a misunderstanding of the way that poor people manage local landscapes for their own long-term benefit (Fairhead and Leach 1996; Forsyth and Leach 1998).
- Likewise, if poverty is defined in terms of cash income or levels of engagement with the formal economy, we may simply underestimate the capacity of 'poor people' to meet their needs outside the formal economy without damaging their natural environment (Reardon and Vosti 1995; Ruggeri Laderchi et al 2003; Gray and Moseley 2005).
- Failure to recognise this kind of capacity may result in the implementation of policies and programs which actually promote the vicious circle which they purport to be alleviating, because they make poor people more vulnerable to environmental shocks (Drèze and Sen 1989).
- Even if poverty is the immediate cause of some kinds of environmental degradation, that poverty may itself be the result of a social, economic or political process, or some institutional configuration, which must therefore be recognised as the ultimate cause (Blaikie and Brookfield 1987; Peet and Watts 1996; Jodha 2001).
- Policies or programs which do manage to combine improvements in *some* people's standard of living with parallel improvements in the quality of their natural environment may have the opposite effect on *other* people who are already less well off (Blaikie and Brookfield 1987; Angelsen and Wunder 2003; Sayer and Campbell 2004).
- Integrated conservation and development projects have not in practice served either to alleviate poverty or halt the process of environmental degradation, and might at best create an illusion of success in situations where no process of environmental degradation was already under way (McShane and Wells 2004.
- Finally, the operation of the downward spiral may seem to be demonstrated by data collected at one spatial or temporal scale of analysis, but then invalidated by data collected at another spatial or temporal scale (MA 2003; Gray and Moseley 2005).

All these considerations now seem to have resulted in an agreement that no single model of the poverty-environment relationship is going to be valid at the national, or even the sub-national, scale, let alone at the global scale (Nadkarni 2001). Many proponents of the downward spiral as *one* model of the relationship would probably say that they have always recognised this fact (Dasgupta et al. 2005). The World Bank's latest 'Environment Strategy' includes a separate annex on 'Poverty and Environment' which concedes that it is not possible to make general statements about the relationship, because both sides of the equation have multiple dimensions, and there are all sorts of local institutional factors which affect the way they are connected to each other (World Bank 2001: 140). The 'Environment' section of the Bank's 'Sourcebook for Poverty Reduction Strategies' delivers a similar message, but harks back to the World Development Report of 1992 by reproducing the original image of the downward spiral and then joining it to an image of the 'environmental Kuznets curve' in order to avoid the suggestion that poverty reduction and environmental protection are natural bedfellows:

> Sometimes poverty can force people to exploit natural resources unsustainably, for example, by forcing them to cultivate on steep slopes, which can lead to erosion and declining yields over time. But increasing income can also lead to overexploitation, for example, by allowing the poor to buy chain saws or bigger fishing boats. The relationships also vary over time. A community can see its income or consumption increase in the short term if it mines natural resources, for example, by felling a mature forest. Over the longer term, however, those practices cannot be maintained (Bojo et al. 2002: 382-3).

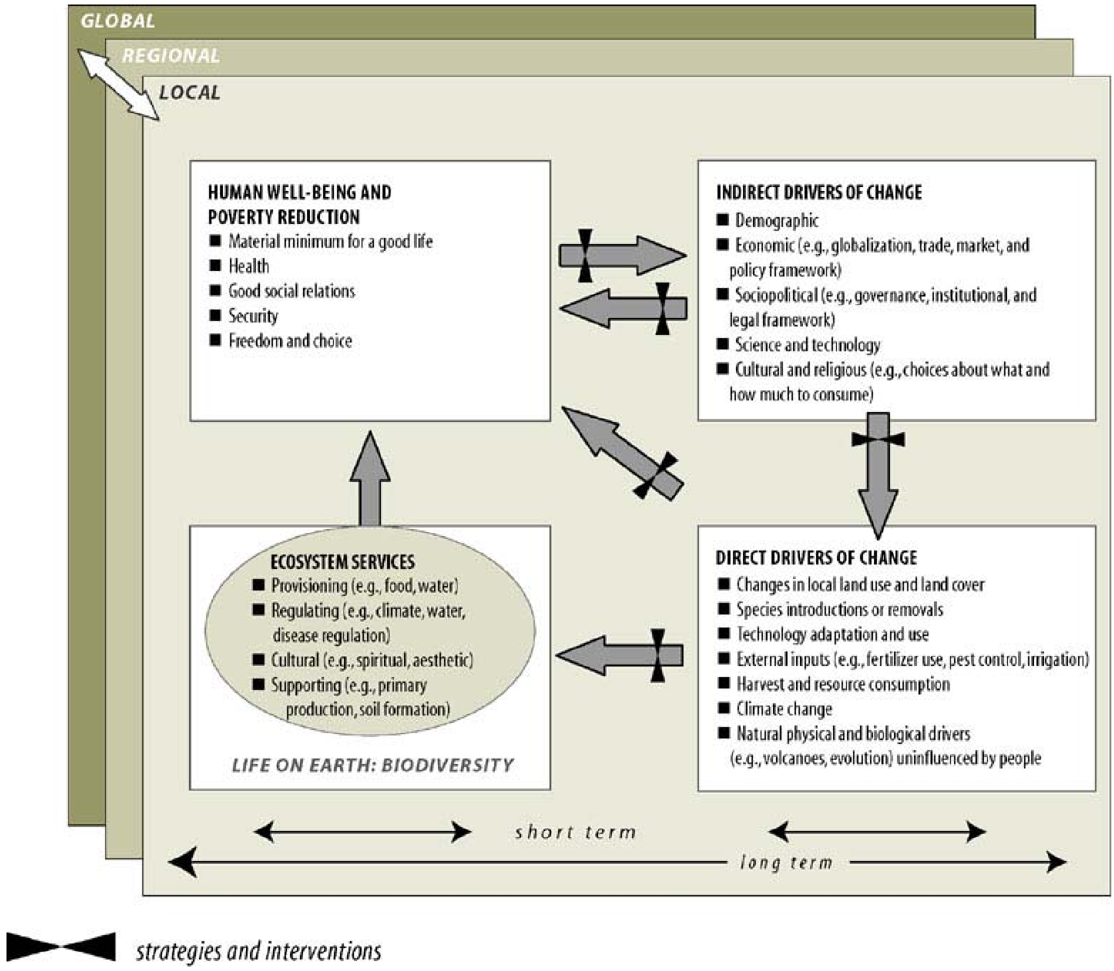
The authors seem to be concerned that an emphasis on the diversity of local institutions and livelihood strategies might be associated with a 'romantic view of community empowerment as the panacea for poverty alleviation and environmental protection' (ibid.: 386). Instead, they take the absence of a single poverty-environment relationship to mean that policies and programs which aim to fix problems on one side of the equation should be insured against the risk of creating more problems on the other side. Even so, this version of the precautionary principle tends to conceal a variety of possible relationships between poverty reduction policies and environmental management policies which reflect the variety of arguments about how poverty and environment are related in the first place (Adams et al. 2004).

Ecosystem Services and Human Well-Being: The Millennium Ecosystem Assessment

In this study, we propose to adopt the conceptual framework of the Millennium Ecosystem Assessment (MA) as a means to understand the variety of poverty-environment relationships that may exist within a specific national context (see Figure 1). This resembles the 'Pressure-State-Poverty-Response' framework proposed by Shyamsundar (2002) as a way of measuring the impact of specific forms of resource degradation on poor people in different local contexts. The MA conceptual framework has four notable advantages:

1. It shifts the focus away from the problematic status or actions of 'poor people' as one section of society to the problem of relating the well-being of human populations to their consumption of ecosystem services.
2. It alerts us to the fact that the relationship between human well-being (or poverty) and environmental quality (or the supply of ecosystem services) may have different properties at different scales.
3. It implies that poverty-environment relationships cannot be 'read off' from a map or a set of statistical correlations, but have to be understood as dynamic elements of a complex system which is constantly changing.
4. Above all, it invites us to ask whether poverty (or the relative lack of well-being) is a driver or an effect of environmental degradation (or any other kind of environmental change), and if it is a driver, how it is related to the other drivers of the same process.

Figure 1: Millennium Ecosystem Assessment Conceptual Framework.



Source: Millennium Ecosystem Assessment 2003: 37.

Instead of trying to define, measure or classify different forms of poverty and different types of environment, and then asking how these two sets of variables might be associated with each other, we propose instead to simplify the nature of the problem by recognising the logical possibility of four basic types of poverty-environment relationship, and only then asking how these might be identified, subdivided, measured or analysed at any particular scale. In other words, we do not try to set a single standard of measurement for each side of the equation, but recognise that there are four possible equations or models, each of which is likely to have its own calculus or dynamic. For the sake of argument, we shall label these as if they were four different types of poverty, but it is important to remember that what we are really talking about is four different types of relationship between changes in human well-being and changes in the quality of ecosystems or environments. To avoid any further confusion on this point, we shall describe each type as a 'syndrome'.

In the *destructive* poverty syndrome, poverty is *both the driver and the effect* of environmental change. People living in destructive poverty are driven to degrade the services which an ecosystem provides, either to themselves or to other poor people, by consuming them at an unsustainable rate or in an unsustainable way, and this in turn brings about a further reduction in human well-being. This is precisely the type of poverty trap that was described as a 'vicious downwards spiral' in the Brundtland Report, even if we make allowance for the possibility that poverty, as a direct or indirect driver of environmental degradation, may itself be the effect of a number of indirect drivers of the kind exemplified in Figure 1.

In the *creative* poverty syndrome, poverty is a *driver but not an effect* of environmental change. This means that the experience or threat of poverty makes people change their behaviour in such a way as to raise their own standard of living *without* degrading the services which an ecosystem provides to themselves or to other poor people. Esther Boserup expounded one version of this relationship in her (1965) study of the 'conditions of agricultural growth', but a number of other versions have been put forward by some of the critics of the downward spiral whose work we have already cited. One important point about this syndrome is that it may tend to be neglected by international aid agencies because it implies that poor people do not need 'aid' when they can solve their problems by themselves.

In the *derivative* poverty syndrome, poverty is an *effect but not a driver* of environmental change. In this case, people are impoverished, not as a result of their own actions, but because the ecosystem services which sustain them are degraded by natural events or by the actions of other people who are *not poor*. This is the type of poverty which counts as an 'external social cost' of resource management regimes from which the victims are excluded. It is also the type of poverty-environment relationship which appeals to those critics of the downward spiral who are inclined to blame the social and environmental problems of developing countries on the consumption patterns of the world's affluent elite.

Finally, in the *conservative* poverty syndrome, poverty is *neither an effect nor a driver* of environmental change. This type of poverty afflicts people who live in an unproductive environment, or depend on the services of an unproductive ecosystem, without the technical capacity or economic opportunity to either damage or improve its productivity. Even if other people are responsible for changes to this type of ecosystem, it is not these changes which are responsible for this type of poverty. People living in the conservative poverty syndrome may manage natural resources in ways are stable, sustainable, and resilient, but none of this behaviour serves to lift them out of poverty. This type of poverty-environment relationship is the one that seems to have received the least attention in the scientific literature, possibly because it represents the complete inversion of the downward spiral.

Our aim in this study is to test the hypothesis that each of these four basic types of poverty-relationship can in fact be found in PNG, and to investigate the spatial relationship between each of these four types at different scales or levels of analysis. However, while we are mindful of the problems associated with attempts to define and measure the attributes of human populations or natural environments in abstraction from any specific model of their mutual relationship, we must also examine the nature and limitations of existing datasets on both sides of the general equation before we can proceed with our investigation. We begin from the side of the environment because it is easier to describe and classify the ecosystems of PNG without making reference to human poverty than it is to describe and classify the human population without making reference to the natural environment.

THE CLASSIFICATION AND MAPPING OF ECOSYSTEMS

Scientific and Political Perspectives on the Definition of an Ecosystem

Article 2 of the UN Convention on Biological Diversity attempts to combine biological and geophysical criteria in its definition of an ecosystem as 'a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit'. The MA Conceptual Framework emphasises the criterion of interaction when it says that 'a well-defined system has key feedbacks included in it and weak, slow, constant, or unidirectional interactions across the boundaries' (MA 2003: 125). However, the possibility remains, at any given scale, that the boundaries of ecosystems defined primarily by reference to *geophysical* criteria may fail to coincide with those whose boundaries are defined primarily by reference to *biological* criteria.

While the MA Conceptual Framework recognises that human populations are themselves to be treated as an integral component of ecosystems (MA 2003: 50), it also treats 'human systems' or 'social systems' as if these were spatially bounded entities which can be 'overlaid' on those of ecosystems (ibid: 125). We take a slightly different approach, by allowing that the human beings who manage ecosystems or consume ecosystem services within a specific society, jurisdiction, or 'level of social organization' (ibid: 108) have their own ways of defining ecosystem boundaries which may not coincide with those postulated by natural scientists. We deal with this possibility by proposing a distinction between *scientific* and *political* perspectives on the definition of ecosystems which cuts across the distinction already made between geophysical and biological perspectives (see Table 4). This fourfold classification may seem puzzling to some environmental scientists, but it reminds us at the outset that the poverty-environment relationship is only one element in the construction of complex 'social-ecological systems' in which human actions and perceptions must always be present in one way or another.

Table 4: Alternative definitions of ecosystems or environments in PNG.

	Geophysical Perspective	*Biological Perspective*
Scientific Perspective	PHYSICAL ENVIRONMENTS	BIOLOGICAL COMMUNITIES
Political Perspective	TERRITORIAL DOMAINS	LANDSCAPE ELEMENTS

In PNG, it makes sense to think of local ecosystems as the territorial domains of human populations or communities because most Papua New Guineans still think of themselves as having the sort of special connection to their ancestral territories that qualifies them as 'indigenous people', as well as 'customary landowners'. In pre-colonial times, their ancestors were members of sovereign political communities which rarely had less than 100 or more than 1000 members. There were perhaps 10,000 of these 'tribal' groups in what is now the State of PNG. The conservative nature of Australian colonial rule means that these traditional communities normally retain a distinctive political identity (as census units or council wards) within the modern institutional framework of the State.

Approximately 98% of PNG's surface area is still held under customary tenure, and is thus divided between the territorial domains of these traditional groups. Even those areas of land which have been alienated for the creation of modern enclaves are still typically seen to belong to the original domains of traditional communities which still exist and still have some claim over them.

The traditional domains of neighbouring communities are very often segments of a larger ecosystem defined from a scientific and geophysical perspective, such as a river valley or a cluster of small islands, but each of these neighbouring domains is then likely to include a similar range of biological communities, which are classified by the human inhabitants as different components of the local cultural landscape. Furthermore, the territorial domains of traditional communities are normally divided between the domains of smaller social groups, commonly known as 'clans' or 'lineages', in such a way as to ensure that each of these smaller groups has access to each of these landscape elements in roughly equal proportions. For example, the clans or lineages within a coastal community may each control a strip of territory stretching from the coastline to the hinterland margin of the whole community's domain, encompassing a range of vegetation types which vary both with altitude and the extent of human interference.

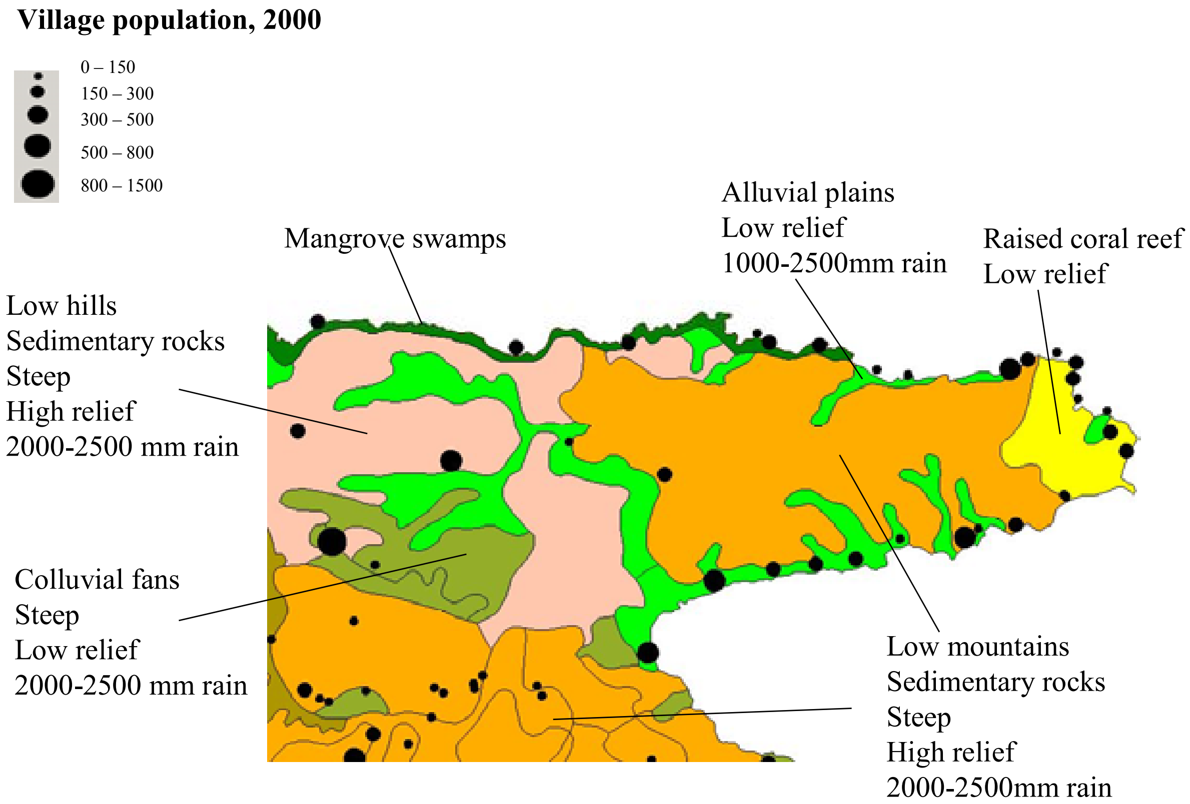
Nowadays, Papua New Guineans also tend to identify with larger territorial groupings of traditional political communities, such as those united by a common language or culture, and hence by a shared understanding of their natural environment. This means that an indigenous political perspective on the definition of ecosystems does not preclude a consideration of poverty-environment relationships at several different scales. Anyone who wants to engage in a meaningful conversation with customary landowners about problems of environmental management must certainly engage with this perspective at some level. Yet there is one obvious drawback to the use of this indigenous perspective as a way of understanding poverty-environment relationships at a regional or national scale. While the boundaries of modern enclaves have been thoroughly surveyed, those of most traditional territorial domains are only known to the customary owners and their immediate neighbours, and the politics of customary tenure is such as to preclude any systematic mapping of their physical boundaries, because of a fear that this will be the first step in a process of alienation. Furthermore, we have only sporadic ethnographic evidence about the way that members of traditional communities actually classify the elements of their local landscapes, but this evidence suggests that their classification of landscape elements, as opposed to plant or animal species, is very similar to that of modern science.

The Classification and Mapping of PNG's Physical Environments

The geophysical variety of PNG's landmass has been classified and mapped at a scale of 1:500,000 on the basis of data collected during the late colonial period by staff of the Australian Commonwealth Scientific and Industrial Research Organisation (Löffler 1977; Bleeker 1983; McAlpine et al. 1983). The results of this work have since been incorporated into a database known as the PNG Resource Information System (PNGRIS), which was primarily intended as a method of determining the potential for sustainable smallholder agriculture in different parts of the country (Bleeker 1975; Hackett 1988; Trangmar et al. 1995), but has also proved to have a range of alternative applications by government agencies with resource management and planning functions (Bellamy and McAlpine 1995).

The physical environments distinguished in this database are known as 'Resource Mapping Units' (RMUs), each of which has been defined as a spatial unit or polygon distinguished from neighbouring units by one or more of six geophysical variables or 'physical resource attributes' -- landform, rock type, altitude, relief, inundation, and mean annual rainfall. However, even this database is not entirely free of a political perspective, because each RMU must also by definition be located within the boundaries of a single province. A total of 4,849 unique RMUs has been identified for the whole of PNG, but if we combine those which are identical except for the fact of being split by a provincial boundary, the number comes down to 4,566, which means that the average area is just over 100km^2.

Figure 2: Resource Mapping Units on Cape Vogel, Milne Bay Province.



Source: PNG Resource Information System.

If we leave the provincial boundaries to one side, we can observe that these physical environments have been defined in such a way that their boundaries can only change very slowly in the absence of massive tectonic disturbances. It is therefore possible to analyse the relationship between physical environments, biological communities, and human activities by mapping biological and cultural information into this geophysical database (see Figure 2). It is also possible to simplify this type of analysis by grouping RMUs into types of physical environment distinguished from each other by reference to one or more of the six defining variables. For example, Table 5 shows the division of PNG's landmass into 14 types of physical environment distinguished by reference to the first variable, landform, and a plausible way of subdividing each of these 14 types in order to arrive at a more detailed classification of the 211 types of physical environment considered in this study.

Table 5: Fourteen major landforms of Papua New Guinea.

LANDFORM TYPE	% PNG	SUBDIVIDED BY:	SUBTYPES
Littoral/Coastal	**4**		
• Mangrove swamps	1	rainfall	3
• Estuaries & coastal plains	0.5	rainfall, inundation	9
• Beach ridges & plains	0.5	rainfall	2
• Raised coral reefs	2	rainfall, relief	7
Plains and Fans	**35**		
• Recent alluvial plains	5	altitude, rainfall, inundation	16
• Relict alluvial plains	13	altitude, rainfall, inundation	6
• Alluvial floodplains	6	altitude, rainfall, inundation	9
• Swamps	8	altitude, rainfall, inundation	11
• Alluvial fans	3	altitude, rainfall, rock type	20
Volcanic	**7**		
• Volcanic plains & fans	5	altitude, rainfall, relief	22
• Volcanic plateaux & cones	2	altitude, rainfall, relief	15
Steeplands	**53**		
• Karst	6	altitude, rainfall, relief	15
• Hills	7	altitude, rainfall, rock type	34
• Mountains	40	altitude, rainfall, rock type	53

It should be noted here that PNGRIS treats altitude as a proxy for temperature, and divides the landmass of PNG into a set of five main altitude classes, each of which has a range of 600 metres, although the two highest classes (above 1800 metres) also have two subdivisions to reflect the sensitivities of alpine cultivation regimes. PNGRIS also treats soil composition as a seventh type of 'physical resource attribute', but does not allow for variations in soil composition to be one of the variables that distinguish between RMUs, because this would create an unmanageable number of spatial units. Instead, each RMU is allowed to consist of one dominant soil type and two subordinate soil types, each of which is described within the database. The descriptive component of the database also specifies the seasonality of rainfall patterns and the probability of drought, as well as the mean annual rainfall class (with 500mm intervals) that is used as a defining variable.

PNGRIS has two notable limitations as a source of information on the geophysical component of poverty-environment relationships in PNG. First, it excludes any consideration of marine environments, which means that it cannot tell us anything about the goods and services which coastal communities might obtain from marine ecosystems.

Second, we cannot tell which communities derive any benefits from the terrestrial ecoystems defined as RMUs because we cannot overlay a map which shows the boundaries of their traditional territorial domains. We can only make a distinction between those RMUs which appear to contain a human population, or at least a census point, and those which appear to be 'unpopulated', even though we know the latter must have customary claimants or controllers.

We cannot do much about the first of these problems, because there has not yet been any systematic classification and mapping of marine environments in any comparable form. But the second problem is addressed to some extent by the way in which PNGRIS includes the use of land (by human beings) in its classification and mapping of biological communities.

The Classification and Mapping of PNG's Biological Communities

The descriptive component of the PNGRIS database attributes one or more 'forest types' or other 'vegetation types' to each RMU, estimates the percentage of each forest type that is 'undisturbed', and makes a separate estimate of the percentage of all land that is 'used' by human beings. This information about biological communities was assembled over the same time period, and by similar methods, as the information used to classify and map the physical environments (Paijmans 1976; Hammermaster and Saunders 1995). The information is condensed in two baseline maps of 'agricultural land use' and 'forest resources', both drawn at a scale of one to a million on the basis of aerial photographs taken in the early 1970s (Saunders 1993a, 1993b).

The first map (Saunders 1993a) shows all the areas of 'cultivated land' and some distinctive types of 'uncultivated land'. 'Cultivated land' is defined as 'all land where there is evidence of a relatively recent cultivation history as indicated by the presence of anthropogenous vegetation'. Different types of cultivated land are distinguished only by reference to degrees of 'land use intensity', except that a distinction is made within the 'very high intensity' class between land dominated by tree crops (coffee, cocoa, coconut or oil palm) and land planted primarily with food crops (such as sweet potato or taro). Within the general category of uncultivated land, the map designates specific areas as grassland, sago groves, savanna woodland, or 'larger urban centres'. The empty spaces on this map, which account for well over half of the total land mass, represent forested areas which are '[c]urrently unused for food crop production but widely used for hunting and gathering'.

It is important to stress that the patches of cultivated land shown on this map, each with its own characteristic level of land use intensity, do not have boundaries that are contiguous with those of RMUs, because land use is not one of the variables used to distinguish between these physical environments. Instead, the description of each RMU tells us what proportions of the land within it have different degrees of land use intensity. But it is easier to relate the vegetation communities shown on the land use map to the human communities shown on a map of census units, because the vast majority of these human communities are either located within the boundaries of a patch of cultivated land or in an urban centre. It therefore seems reasonable to assume that the collection of people who live within the boundaries of a patch of cultivated land are the people who cultivate it, and in the case of customary land, to make the further assumption that they are the customary owners of that land. What this map cannot tell us is the extent of the claims made by each of these collections of people on adjoining areas of cultivated land which appear to contain no human settlements or adjoining areas of forest which do not shown any sign of cultivation.

The related map of forest resources (Saunders 1993b) divides areas of forested land into six major categories distinguished primarily by their altitudinal range. In this case also, it is possible for a single RMU to include forests of more than one type or sub-type, but this is not very common for two reasons: first, because altitude is already one of the variables used to define physical environments, and second, because forest or vegetation types are used as a proxy to determine that type, frequency and duration of inundation or flooding, which is another of the variables used to define physical environments. This last point explains why mangrove swamps show up as a distinctive type of RMU, as well as a distinctive form of vegetation on the map of forest resources (see Figure 2 and Table 5). Sago groves are not recognised as a distinctive forest type, but some of the areas allocated to sago groves on the land use map are also allocated to one of the forest types distinguished on the forest resource map. Likewise, some of the areas shown as 'cultivated land' on the land use map are classified as forested land on the forest resource map because they are areas of significant secondary regrowth following cultivation.

Some of the architects of the PNGRIS database have also been involved in the production of a second database, which is a full-fledged geographical information system known as the Forest Inventory Mapping System (FIMS). This is intended to assess the potential for commercial forestry operations, in much the same way that PNGRIS was intended to assess the potential for smallholder cash cropping, in different parts of PNG, and is thus hosted by the PNG Forest Authority, rather than the Department of Agriculture and Livestock. There is also a difference of scale, because FIMS maps forest resources and vegetation communities at a scale of 1:100,000, instead of the broader PNGRIS scale of 1:500,000. The FIMS baseline was constructed by reanalysis of the aerial photography already used to construct the earlier land use and forest resource maps (Saunders 1993a, 1993b), but excluding those areas previously classified as urban centres, cultivated land, or unvegetated land. The remaining areas, which comprise about 70 percent of the total landmass, were then divided into Forest Mapping Units (FMUs), each of which is a subdivision of a single RMU in PNGRIS. Because of the difference in scale, FIMS is able to allocate each FMU to one of 59 distinctive types of vegetation community, of which 36 (including mangroves) are classified as forest types (Hammermaster and Saunders 1995).

A combination of satellite imagery with rapid air and ground surveys undertaken in 1996 was then used to map the extent of change in the extent and composition of forest cover in each of these units since 1975. This map shows, amongst other things, that roughly 8 percent of PNG's total forest area had been subjected to some form of selective logging in the intervening period, while another 3 percent had been permanently converted to other forms of land use, primarily commercial and subsistence agriculture (McAlpine and Quigley 1998). Since the main purpose of the database is to indicate the potential for additional logging operations which do not result in permanent environmental degradation or conversion, FIMS also shows which areas should be excluded from such operations, either because of physical environmental constraints which have already been mapped in PNGRIS or else because they are already designated as protected areas by the PNG Department of Environment and Conservation.

The descriptive component of FIMS includes an estimate of the relative percentages of commercially valuable tree species which are present in each FMU. This information was derived from field surveys, rather than aerial photographs or satellite data, and is therefore very uneven in quality. However, it has enabled the architects of the system to elaborate on the classification of 'forest types' by grouping the FMUs into 42 'forest zones' distinguished by species composition, as well as by structural features (Hammermaster and Saunders 1995). This is as close as the database gets to a classification of forest habitats which might be used to predict the presence of animal and bird species in the absence of variations in the form and extent of human predation. However, this classification of biogeographical regions does seem to represent a refinement of the broader regional distinctions made by international conservation organisations whose primary interest is the mapping of 'biodiversity values'.

The mapping of biodiversity values at a national scale was first attempted through a 'Conservation Needs Assessment' implemented by the Biodiversity Support Program at the request of the national government (Alcorn and Beehler 1993). Three maps were produced as a result of this exercise – one showing 'biologically important' terrestrial and wetland areas, a second showing 'marine priority areas' and 'critical watersheds', and a third showing 'major unknown areas'. The first two maps still decorate the walls of several conservation organisations in PNG. Since these maps are drawn at a very broad scale indeed, and the significant areas are not distinguished by any systematic set of criteria, it is not possible to reconcile them with the maps produced in the development of PNGRIS and FIMS.

A team of Australian scientists has since devised a more sophisticated model of the distribution of PNG's biodiversity values, which is generally known 'BioRap' because it is meant to be a tool for the rapid assessment of biodiversity priority areas. In contrast to the databases which house the family of maps related to PNGRIS, this is a raster-based geographical information system, with a cell size of approximately one square kilometre, which allows for the matching of environmental and biological information at different scales. Information about the physical environment was mapped onto a digital elevation model, which was then used to predict the distribution of selected plant and animal taxa from knowledge of the sites where specimens had previously been collected. The point of this exercise was to determine a flexible scheme of 'trade-offs' between the spatial distribution of biodiversity values, the temporal change in patterns of land use which threaten the conservation of these values (especially commercial logging), and the policy choice of which areas to conserve in order to maximise the conservation of biodiversity values within a fixed proportion (say 10 percent) of the country's total surface area (Nix et al. 2000; Faith et al. 2001). Although this database could in theory be used to analyse the biodiversity component of poverty-environment relationships, it has so far been treated as a decision-making tool for planning new protected areas, and the Department of Environment and Conservation has not been able to make much use of it because this kind of land use planning assumes a degree of collaboration between government agencies, conservation organizations, and customary landowners which cannot be produced by a computer (Vovola and Allen 2001).

PRODUCTION SYSTEMS AND RESOURCE MANAGEMENT REGIMES

Food-cropping Systems or Indigenous 'Agro-ecosystems'

From 1990 to 1996, a team of geographers at the Australian National University organised a thorough field survey of smallholder 'agricultural systems' in all areas previously designated as 'cultivated land' on the PNGRIS land use map (Saunders 1993a). Since this 'Mapping Agricultural Systems Project' (MASP) did not cover agro-industrial enclaves such as oil palm estates, and was primarily concerned with the dynamics of local food-cropping systems, rather than smallholder production of export crops, we may regard it as an exercise in the classification and mapping of local or indigenous 'agro-ecosystems' (Conway 1987) within the generic biological community of cultivated land or the legal category of customary land.

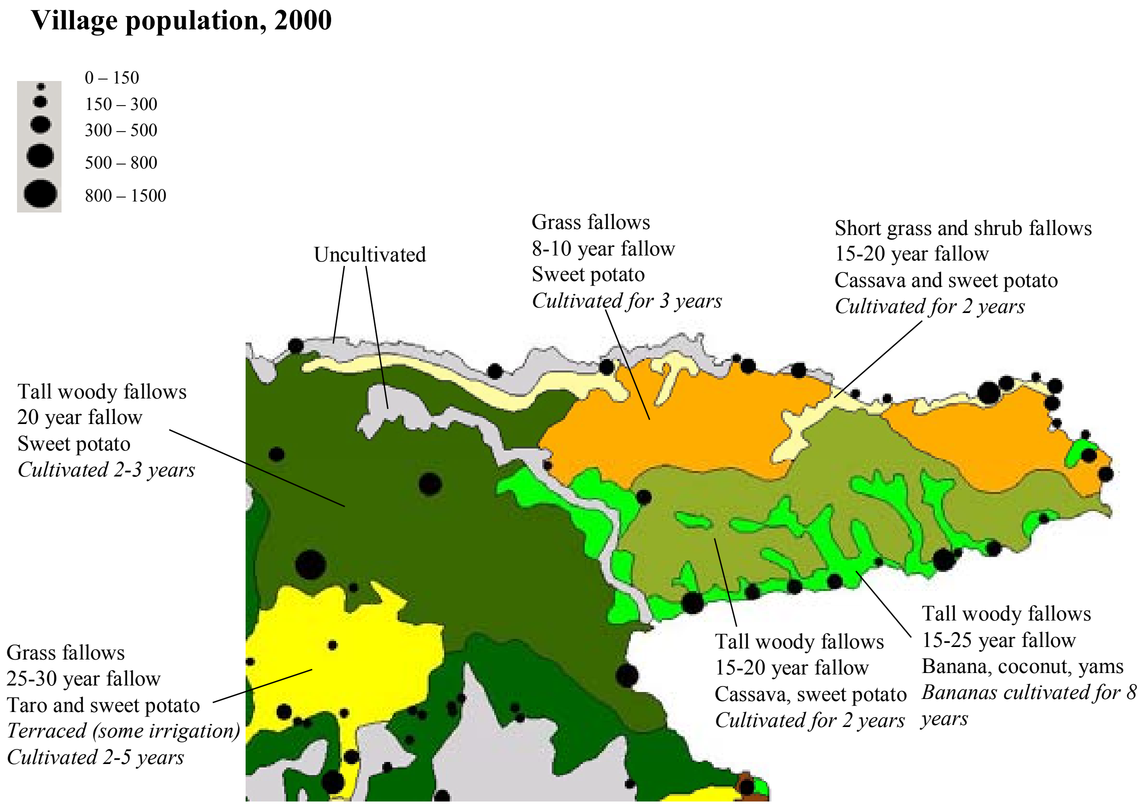
Each of the agricultural or food-cropping systems distinguished in the MASP database has been defined as a unique combination of six variables related to the measurement of 'agricultural intensity':

- the fallow vegetation type cleared from garden sites at beginning of planting;
- the number of times land is planted before being fallowed (the cropping period);
- the period of time the land is fallowed (the long fallow period);
- the most important or dominant crops in the system;
- the techniques used to maintain soil fertility (other than fallowing); and
- the segregation of crops within or between garden sites.

The same system may occupy one or more of the discrete areas of cultivated land distinguished on the earlier land use map, but, as in the case of RMUs, provincial boundaries are treated as the seventh variable in the definition and classification of these systems. A total of 343 unique food-cropping systems has been identified for the whole of PNG, but if we combine those which are identical except for the fact of being split by a provincial boundary, the number comes down to 287 (Bourke et al. 1998).

Figure 3 shows the distribution of food-cropping systems in the same part of the country that was previously used to illustrate the classification of physical environments in PNGRIS. Comparison of Figures 2 and 3 illustrates a point already made, that we should not expect the boundaries of 'agro-ecosystems' to match those of RMUs, because land use is not one of the variables used to distinguish between these physical environments. This point also has some theoretical significance, because any artificial attempt to align the two sets of boundaries would beg the question of whether and how specific food-cropping practices are in fact influenced by physical environmental conditions (Vovola and Allen 2001). Or to put the same point in another way, it would assume a questionable coincidence between the boundaries of local ecosystems defined by geophysical and biological criteria, when it is known that biological communities have been modified by human activity, and the generic biological community of cultivated land has been modified to a very significant extent.

Figure 3: Food-cropping systems on Cape Vogel, Milne Bay Province.

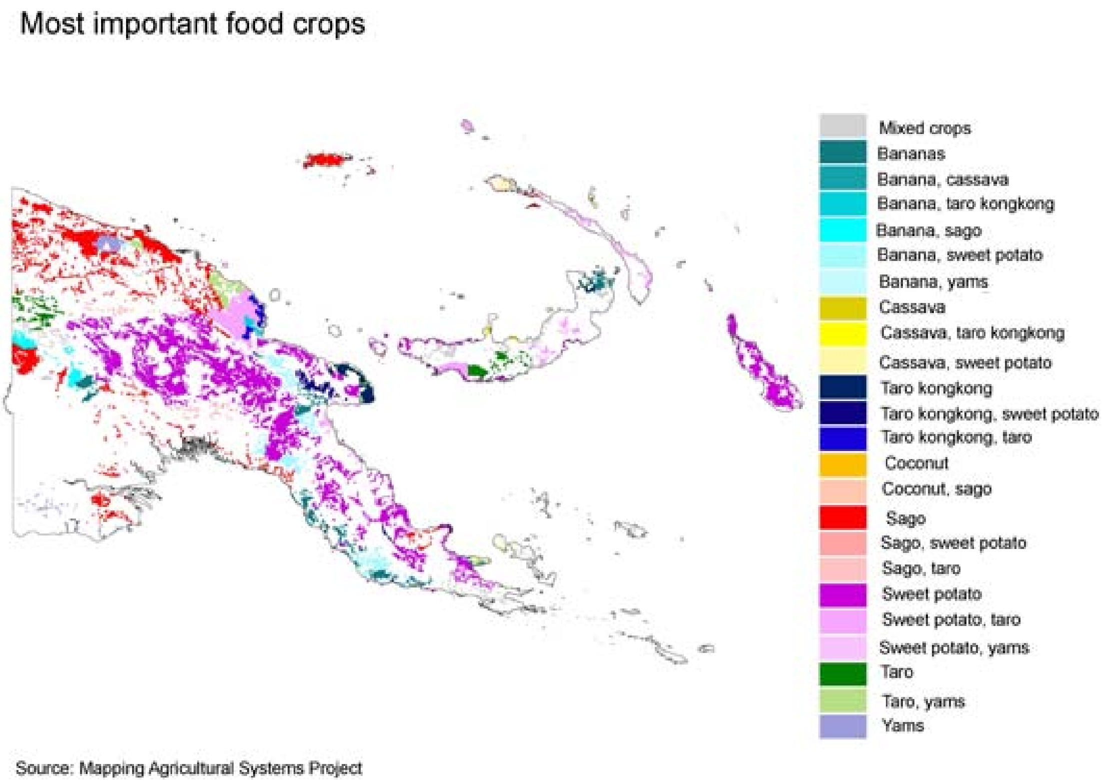


Source: Hide et al. 1996.

The difference between PNGRIS and MASP is also illustrated in their approach to the problem of measuring 'land use intensity'. While PNGRIS divides each RMU into areas which showed different degrees of human disturbance on the aerial photographs taken in the early 1970s, MASP follows Ruthenberg (1980) in calculating land use intensity as a function of the cropping periods and long fallow periods that were identified by field surveys during the early 1990s, and then adopted as two of the variables used to distinguish food-cropping systems from each other (Bourke et al. 1998).

The role of traditional communities and groups in the development, management and understanding of these food-cropping systems means that the MASP database provides the best available source for a systematic survey of local ecosystems defined by a combination of *political and biological* criteria, as a set of 'social-ecological systems' rather than a set of biological communities with human interference treated as an 'external' variable. On the other hand, the database also provides a set of scientific, rather than political, criteria for grouping traditional communities together on the basis of their 'culture of cultivation'. Just as RMUs can be grouped into types of physical environment distinguished from each other by reference to one or more of the six variables used to define them in the first place (see Table 5), so we can aggregate food-cropping systems by reference to one or more of their six defining variables. Thus, for example, the most important or dominant crop can be used to distinguish, at a very broad scale, between 'sweet potato systems', 'sago systems', and the like (see Figure 4), if we agree to overlook the diversity of crops cultivated in most of these systems.

Figure 4: Spatial distribution of staple crops in PNG's food-cropping systems.



As in the case of PNGRIS, the MASP database contains a variety of additional variables which have been mapped into the food-cropping systems without being used to define their boundaries. These include the gross human population data which have also been mapped into PNGRIS (see Figures 2 and 3), which means that we can calculate the crude population density of each food-cropping system, as well as each RMU. Although it makes more sense to calculate the density of population on areas of cultivated land, rather than physical environments distinguished without reference to any human activity, there are still some parts of the country where the location of census units does not seem to reflect the numbers of people engaged in adjacent food-cropping systems (see Figure 3), and in these cases, the MASP database includes provision for adjustments to be made in the relative populations of these systems. The MASP database also includes a number of other variables which relate to the socio-economic status of the population associated with each system, such as levels of outmigration, estimated cash earnings from agricultural activities, and the accessibility of the nearest service or market centre (Hanson et al. 2001). We shall return to a discussion of their significance when we consider the definition and measurement of rural poverty.

Indigenous and Industrial Production Systems

Since the MASP database includes information on a variety of agricultural (and even non-agricultural) activities which yield a regular cash income for the rural populations engaged in each food-cropping system, and the production of export crops by smallholders is normally part of a single integrated farming system, we can reasonably say that this database represents the spatial distribution of indigenous *agricultural* systems, and not just *food-cropping* systems, at least within the rural sector. The database does not contain much information on the widespread practice of food-cropping in the major urban centres (Battaglia 1986; Levett 1992), partly because these areas were excluded from the generic category of 'cultivated land' in the PNGRIS land use map, and partly because it is very difficult to link distinctive urban food-cropping systems with distinctive segments of the urban population, especially if this needs to be done at the MASP mapping scale of 1:500,000.

The distinction made here between industrial and indigenous production systems is not to be confused with the distinctions commonly made between the 'cash' and 'subsistence' sectors, the 'modern' and 'traditional' sectors, or the 'formal' and 'informal' sectors of the national economy. That is because the farming or agricultural systems described in the MASP database clearly straddle all three of these alternative divisions. The prospect of sale does not have much influence on the way that food is produced in each of these systems; there is abundant evidence of innovation in the selection of crops and cropping techniques, both before and after the advent of colonial administration; and smallholders can and do participate in the 'formal' sector of the economy through their interactions with large-scale industrial producers or national marketing bodies (Allen et al. 1995; Bourke 2001). The defining characteristic of indigenous or 'home-grown' production systems is not the fact of their existence in the pre-colonial era, but the fact of their being effectively controlled or managed by the customary owners of customary land or resources. In those few cases where so-called 'urban squatters' are able to cultivate customary land without the permission of its customary owners, we would have to say that they are engaged in an informal or illegal activity which does not belong to either of the types of system distinguished here.

Within the agricultural sector, we could say that there is one industrial production system for each of the major export crops, but the oil palm industry stands out from the rest by virtue of its growth trajectory, its internal organisation, and its economic relationship with the smallholders cultivating oil palm within their indigenous production systems. There are also some minor export crops, such as vanilla, which are monopolised by indigenous agricultural systems. While the Medium-Term Development Strategy may be right to assume that agricultural production systems are and will remain the backbone of the national economy, the distinction between indigenous and industrial production systems can also be drawn in a number of other sectors which are relevant to the analysis of poverty-environment relationships because of their economic and environmental significance. There are three sectors – mining, forestry, and fisheries – in which a single, large-scale industrial system has one or more indigenous counterparts, because alluvial mining, small-scale logging and sawmilling, and artisanal fishing activities are known to make a substantial contribution to rural livelihoods in some parts of the country. The oil and gas industry does not have an indigenous counterpart, unless one counts the traditional harvesting of mineral or vegetable oils for bodily decoration, and there are some indigenous production systems outside the agricultural sector – most notably 'hunting and gathering' systems – which have no industrial counterpart.

There are three types of relationship between industrial and indigenous production systems which coexist in the same economic sector. At one extreme is the relationship between nucleus estates and smallholders in the oil palm industry, where the industrial system plays an active role in supporting the indigenous system through the supply of inputs and purchase of outputs (Koczberski et al. 2001). At the opposite extreme is the relationship between the large-scale mine and a small army of small-scale miners at Porgera, where the two sides are occasionally engaged in armed conflict over access to resources within the company's Special Mining Lease. In most cases, however, including the rest of the mining sector, the relationship does not involve active collaboration or actual conflict, because industrial and indigenous systems operate independently of each other, both in spatial and economic terms.

The physical extent of large-scale mining, petroleum and logging operations can be inferred from maps showing the boundaries of the relevant licence areas or concessions, although we need additional information in order to specify the actual location of industrial activities at any particular moment in time. A good deal is also known about the social, economic and biophysical impacts of all large-scale mining and petroleum projects because the national government and the operating companies have a common interest in measuring these impacts. Where this common interest seems to be lacking, as in the renewable resource sectors, information on this subject varies enormously between different industrial operations, and for many it is simply non-existent. And there is even more of a black hole in the spatial and statistical datasets available for indigenous production systems outside of the agricultural sector.

For example, it is estimated that there could be anywhere between 50,000 and 100,000 small-scale and artisanal gold miners in PNG, although many of them only work on a part-time basis (Susapu and Crispin 2001). Between them, they produce approximately 70,000 ounces of gold each year which is exported through legitimate channels, and perhaps half as much again which is exported without licence. At current prices, this means that their production is worth more than the combined value of the copra, tea and rubber exported from PNG, or roughly half the value of the country's coffee exports. Artisanal mining is known to pose a variety of environmental and physical hazards, most notably those arising from the use of mercury, and the use of mercury might be one of the variables used to distinguish between different types of indigenous mining system, yet we do not have enough data to make a systematic classification.

A similar problem arises with the classification and mapping of other indigenous production systems outside of the agricultural sector. It makes no sense to think of these as systems which could simply be added in to the existing map of indigenous agricultural systems if we had sufficient information about them, precisely because they normally involve the harvesting of resources which are not located on areas of 'cultivated land'. We could perhaps say that each of the populations involved in a particular food-cropping system is also involved, to a greater or lesser extent, in one or more of these other indigenous production systems, but we also know, from local ethnographic studies, that some of the local communities associated with a particular food-cropping system may actually specialise in the production of something other than food crops as part of a regional division of labour. For example, we know that there are some communities settled on very small islands or along the banks of major rivers who have specialised in the production and exchange of fish in order to secure their supplies of vegetable food from neighbouring communities (Carrier 1982; Gewertz 1983; Macintyre and Allen 1990).

A somewhat different problem arises in the case of the many other groups scattered around the lowland and mid-montane interior of the main island of New Guinea who could be described as 'hunter-gatherers' because of the extent of their dependence on the exploitation of wild sago palms (Roscoe 2002). These people have been accommodated in the MASP database as practitioners of a distinctive sago production system, despite their lack of association with any areas of cultivated land on the PNGRIS land use map, and it might even be possible to distinguish a number of discrete sago systems by the relative intensity of sago management practices (Townsend 2003). However, it is very hard to assess the relative extent of people's dependence on the hunting of wild animals or the gathering of wild vegetable foods (aside from sago) in any of the agricultural systems distinguished in this database.

In the absence of any systematic survey data at a national scale, we have no choice but to extrapolate a classification and mapping of these 'marginal' production systems from local case studies in different parts of the country. As in the case of food-cropping systems, we may opt for a subdivision of indigenous mining, hunting or fishing systems by reference to the means or methods of production and the frequency or intensity of productive activity. In making the extrapolation, we then need to recognise that each system and subsystem is likely to be associated with a different set of ecosystems. For example, the incidence of alluvial gold mining is likely to be associated with a subset of RMUs distinguished by landform and rock type, while the frequency or intensity of hunting activity is most likely a function of low human population densities in association with certain types of biological community. It certainly makes more sense to allow for some kind of relationship between the spatial distribution of ecosystems and indigenous production systems of all types than to use one or two local case studies to predict the behaviour of a very large segment of the total rural population (Mack and West 2005).

Finally, there is a risk that, in our effort to flesh out the classification and mapping of indigenous production systems which are not agricultural systems, we shall be misled by the idea of a 'system' as something which retains its distinctive features in a particular location for a considerable period of time, or in which the elements of innovation and evolution have a systematic quality. The well-known example of the Mount Kare gold rush in 1988 should alert us to the possibility that some indigenous production 'systems' might better be thought of as creatures which migrate around the countryside, changing their human shape and size with great speed as new resources are discovered, exploited and exhausted in short periods of time. Another counter-example would be the harvesting of eaglewood or agarwood, which is perhaps the least traditional of all 'indigenous production systems', because it feeds on a resource whose existence and value was apparently unknown to any Papua New Guineans before 1998, and the economic consumption of this resource by people who have access to it could be finished within a few years (Gunn et al. 2004). This type of productive activity might therefore be seen as a set of alternative livelihood strategies which occasionally suck some people or their labour out of the indigenous production systems that normally sustain them.

Local and Sectoral Resource Management Regimes

The distinction already drawn between indigenous and industrial production systems can be aligned with a parallel distinction between local and sectoral resource management regimes (see Table 6). A resource management regime is defined here as the set of values, policies, institutions and practices which are applied to the human consumption, management, conservation or exploitation of specific natural resources, landscapes or ecosystems. Having defined indigenous production systems in terms of the control exercised by the customary owners of customary land or resources, we might now say that local resource management regimes are defined and classified by reference to the form of control which members of local communities exercise over their territorial domains. While local management regimes may thus embrace a number of indigenous production systems distinguished in terms of their specific outputs or techniques, sectoral management regimes are defined and classified by reference to the multiple forms of control exercised over specific types of production or consumption at different levels of social and political organisation.

Table 6: Production systems and resource management regimes.

	'Community'	*'Society'*
Production Systems	INDIGENOUS SYSTEMS	INDUSTRIAL SYSTEMS
Management Regimes	LOCAL REGIMES	SECTORAL REGIMES

Given that we are now dealing with the realm of policy, as well as the realm of practical activity, it makes sense to classify sectoral resource management regimes by reference to those national government agencies whose official policies may themselves be drivers of environmental change. While students of international relations sometimes distinguish global 'regimes' by reference to international agreements, such as the Convention on Biological Diversity (Young 1997), our focus here is on the link between decision-making systems at different levels, from the global to the local, and national governments normally engage with international agreements through specific sectoral agencies. At the national level, we can make a broad distinction between *primary industry* regimes, in which government agencies are responsible for the regulation of specific economic sectors, like the agricultural or mining sectors, and what we might call *landscape management* regimes, which would include the landed property, environmental protection, and urban development regimes.

Although we may take the existence of a separate national government department as evidence of the existence of a sectoral management regime, this does not mean that the government has a monopoly over the design or implementation of the policies which belong to this regime, let alone the values, institutions or practices which are associated with them. It only functions as a point of reference because other actors or stakeholders recognise the power of a national government to establish general rules about the consumption, management, conservation or exploitation of specific natural resources, landscapes or ecosystems – even if these rules are often broken in practice.

A sectoral regime engages multiple actors, stakeholders or decision-makers, each of whom may operate at several different levels or scales. For example, the *environmental protection* regime, which is the notional responsibility of the PNG Department of Environment and Conservation, may involve officers of that department in global debate about the application of the Convention on Biological Diversity, or in purely local debate about the establishment of a 'Wildlife Management Area' under PNG's *Fauna (Protection and Control) Act*. Other actors in this regime might include the World Bank, in its capacity as the manager of a grant from the Global Environment Facility, or the villagers who apply to establish a Wildlife Management Area, or staff of the WWF South Pacific Program who encourage them to do so. Each sectoral regime therefore has institutional components at different levels of management or administration, and covers a variety of cross-scale linkages between institutional systems which affect the consumption, management, conservation or exploitation of different ecosystem services.

The definition and classification of ecosystems within a specific national context may itself be the work of people involved in a specific sectoral management regime. As we have seen, the classification of physical environments and biological communities in PNGRIS is a function of the country's *agricultural management* regime, because the Australian scientists who invented the system were mainly interested in mapping the potential for sustainable smallholder agriculture. On the other hand, the fact that members of traditional communities know and control the boundaries of their traditional domains, while the government has never contrived to map these 'ecosystem' boundaries in any systematic way, is a feature of the country's *landed property* regime.

Sectoral resource management regimes, or the people who work to sustain them in their present form, may also be held responsible for shaping the poverty-environment relationship itself. For example, some commentators believe that the landed property regime, and all the local resource management regimes that hide behind it, work to preserve poverty because customary land tenure is the major obstacle to economic development (Curtin 2004; Gosarevski et al. 2004). Others, as we have seen, suggest that the mineral resource management regime, in its present form, promotes a form of economic development whose human and environmental costs amount to a 'resource curse' upon the nation (Hyndman 1994).

If we approach the definition and classification of resource management regimes from a governmental point of view, we must then ask whether the critics of current government policy are themselves part of the regime which they criticise, and therefore members of the 'policy community' associated with it. The main reason for giving a positive answer to this question is that PNG government officials and their political masters are rarely united in their own understanding and application of the laws and policies for which they are responsible. But then we must abandon the idea that a sectoral resource management regime is based on a *single* set of values, policies, institutions and practices shared by all members of the relevant policy community, and say instead that what they have in common is an *argument* about such things which constitutes a single policy *process* (Filer and Sekhran 1998). That is how Greenpeace and Rimbunan Hijau, for example, both qualify as organisational members of PNG's forest policy process and forest management regime.

This helps to explain why it is difficult to identify a single *national* resource management regime which integrates different sectoral regimes at a national level. Of course we can talk in very general terms about the provisions of the national constitution or the politics of extractive industry, but most of the people who actually participate in any relevant policy process at the national level normally do so within the confines of one or two specific sectors, including the 'environmental' one. If the policy process therefore seems somewhat chaotic at the national level, can we assume that it is any less chaotic at 'lower' levels of political or social organization?

This assumption is often made by people who talk about 'local communities' or 'customary landowners' while they participate in the political debates which constitute a sectoral resource management regime. Many of these people, being Papua New Guineans, would say that they have a perfect right make this kind of assumption because they *are* customary landowners and members of specific local communities. Nor is there any sectoral regime in PNG – even the urban development regime – which can ignore the values, policies, institutions and practices of customary resource owners. The participants in these sectoral regimes therefore tend to construct and debate ideas about the way that cross-sectoral local resource management regimes are actually managed.

In practice, it seems safe to say that most of the decisions made about the management of natural resources at a local or community scale are made by their customary owners, but this does not necessarily mean that they are made by a 'local community', or even by its representatives. That is why we may be led astray if we choose to describe local resource management regimes as 'communal' or 'collective' regimes. Some groups may have chiefs or leaders who act as the managers of their collective property, but others may simply share a set of values and institutions that allows each household or family to make its own resource management decisions. In the latter case, a management regime is not something imposed by a central authority, even at very local level, but the observed effect of multiple livelihood strategies. In a situation of rapid social change, where the individual members of a rural community are able to pursue quite different livelihood strategies, we may also be led astray if we choose to describe local resource management regimes as 'indigenous' or 'traditional' regimes, precisely because traditional leaders may have lost much of the local influence which they once possessed. So local regimes might turn out, like their sectoral counterparts, to be bundles of disputes, rather than forms of collective action. The difference would be that the participants in a strictly local 'policy process' normally recognise each other as members of a group whose territorial boundaries are not themselves subject to dispute, and their arguments therefore focus on the bundle of resources contained within that local landscape.

An external observer might try to classify and map the distribution of local resource management regimes by reference to the values, institutions, or arguments which they have in common, in the same way that indigenous food-cropping systems have been classified and mapped by reference to a number of technical variables. But we do not possess the information required to accomplish this task unless we assume a neat correspondence between indigenous food-cropping systems and the local management regimes. We might be tempted to make this assumption on the grounds that PNG is essentially a 'nation of gardeners', and the way that customary landowners make decisions about the use of their land for cultivation provides us with many clues about the way that they integrate the practice of cultivation with other resource management practices, such as fishing, hunting or forest management.

However, there are several reasons to question and qualify the idea that local resource management regimes involve the horizontal integration of decisions about the management of indigenous production systems, while sectoral regimes involve the parallel but vertical integration of decisions about the management of industrial production systems. As we have seen, there is no reason to assume that either type of regime involves the *integration* of values, decisions or institutions. Furthermore, resource management regimes are defined in terms of the way that people manage (or dispute) the consumption of different ecosystem services, while production systems are distinguished primarily in terms of their physical outputs and environmental impacts. Even those sectoral regimes that we have classified as primary industry regimes are not simply concerned with the management of industrial production systems within a specific economic sector, but with the way that certain types of resource, such as minerals or forests, are consumed by *both* industrial and indigenous productions systems.

Just as customary landowners and local community members play an active role in all sectoral management regimes, so can industrial production systems and their consumption of ecosystem services become the subject of local management regimes. The values and policies which constitute a local regime may include a stated preference for industrial over indigenous production systems, as when rural villagers say that they would rather sell their trees to a big logging company than keep them for some other purpose. And even if they do not all share this preference, the choice between industrial and indigenous production systems may still be a central subject of division and debate within a local community and its resource management regime. So the construction of Figure 6 should not lead us to think that the relationship between local and sectoral regimes is simply a 'reflection' of the relationship between indigenous and industrial production systems. Instead, the relationship between indigenous and industrial production systems must be understood as one of the subjects for reflection, argument and management in each type of management regime.

If the relationship between industrial and indigenous production systems can also be characterised as one of active incorporation, mutual antagonism, or general indifference, how then should we characterise the relationship between sectoral and local resource management regimes? The distinction commonly drawn between 'top-down' and 'bottom-up' approaches to policy and planning might easily lead us to assume that local regimes are located at the bottom of a hierarchy in which the relative power of managers or decision-makers is determined by the level of political organization at which they typically operate. But there several reasons to doubt whether this kind of assumption can make sense of the policy process in PNG.

We have already pointed out that customary landowners and local community members participate at all levels decision-making in PNG because most citizens employed in the formal sector of the economy would also identify themselves as customary landowners and as members of a traditional rural community. They do not have to leave these identities behind when they participate in sectoral resource management regimes, and they are not without influence in the local regimes of their own traditional communities, even if that influence is often exercised at a distance. The retention and reinvention of ethnic identities within the framework of the nation state means that it is difficult to assign individual managers or decision-makers to any particular level within a political hierarchy because each has vertical ethnic connections which are often more significant than the horizontal links with other people who are formally engaged in the same kind of work. At the same time, there are major constraints on the ability of people who are formally employed at the national or provincial level of a sectoral management regime to influence the behaviour of the vast majority of customary resource owners who are *not* members of their own community or ethnic group, because the State itself can barely claim a legitimate role local management regimes. And finally, the chaotic nature of the policy process associated with each sectoral management regime may itself be a reflection of the equally chaotic nature of the policy process associated with many, if not most, of the multitude of local management regimes, or else a reflection of the great diversity of values, institutions and practices which are contained within them.

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