ENVIRONMENTAL IMPLICATIONS OF LIVESTOCK PRODUCTION IN PAPUA NEW GUINEA

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ABSTRACT

Papua New Guinea (PNG) has a 5000 year history of the integration of livestock into subsistence food crop farming systems. The potential for significant environmental impacts only appeared with plantation agriculture and cattle ranching some 110 years ago. Even then, the impacts have been minimal but have been increasing over the last 30 years or so due to population pressures on agricultural land use. Global concerns over the sustainability of mixed crop-livestock systems are of relevance in PNG due to intensification of land use and reduction in the capacity of traditional responses to cope. The effective integration of livestock into cropping systems has been and will increasingly be one of the more important coping strategies. Mixed farming allows for the recycling of nutrients and the effective utilization of waste products from all sectors of the system. The likely future scenario is for increasing intensification together with increasing demand for livestock products. Options to meet these demands include more effective use of underutilized animal feed resources, including crop by-products, pasture improvement on existing grazing land, more effective use of fallows and multi-purpose tree species, and the efficient recycling of animal manures.

Key Words: *Livestock production; intensification; environmental impact; sustainability, animal manure.*

INTRODUCTION

For the purposes of this paper it is necessary to consider separately the impact of the introduction of livestock into the Papua New Guinea environment, the current situation and the environmental implications of the possible or likely development pathways for livestock production in the future. Livestock here includes those domestic animal species currently important for meat or egg production and those, such as the rabbit, showing some promise for the future.

Historical Impacts

Historically the impact of domestic animals has been small or localised. Prior to the introduction of new species by colonial administrations and settlers (effectively pre -1880), domestic animals were confined to pigs, dogs and chickens. Environmental disturbance was almost entirely the consequence of the hunting and gathering activities and the clearance of land for gardening by people. That the consequences of perhaps 40,000 years of human occupation and 10,000 years of gardening have been substantial is evidenced by species extinction, reduction in returns from hunting and the replacement of rainforest by anthropogenic grasslands (Flannery 1994, Vasey 1989, Lea 1976, Henty 1969). Loss of rainforest habitat became increasingly serious with the population increases and expansion of agriculture following the introduction of sweet potato some 400 years ago (Allen *et al.* 1995).

It might be expected that chickens have had little or no effect on the environment. Domestic pigs and pigs gone feral have an impact associated with human activities in that they continue to disturb fallow land and forest peripheral to gardens after the completion of the garden cycle. Dwyer (1978) documents the results of a detailed study on the changes in the distribution and abundance of rodent species resulting from reduction and increased patchiness of forest, increased grassland and local habitat disturbance due to the activities of pigs and humans at an altitude of 2000-2500 m. While it is not sensible to separate the effects of these two species, the suggestion is that pigs maintain the disturbance after completion of gardening or woodcutting. Pigs can subsist on the wide range of edible items found in the rainforest. However, provided the populations remain low due to nutritional and genetic factors, and to hunting pressure, the damage should remain minimal.

Dogs, introduced probably some 3,500 years ago, are only important in terms of their role in increasing the efficiency of hunting and this may have had local significance in prey depletion. Titcomb (1969) gives a fascinating account of the role of dogs in traditional Pacific societies. The hunting of feral pigs was an important activity where they inhabited secondary

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vegetation and the fringe zones of primary forest, especially at lower altitudes i.e. below 1200m. This is described for Maring speaking peoples of the lower Bismarck Ranges by Clarke (1971) and, for a contrasting society, the Siuai of Bougainville by Oliver (1955). Flannery (1994) suggests that wild dogs (presumed originally from domestic stock) were responsible for several mammalian extinctions in the high altitude grasslands.

European colonists found a foot-hold in Papua New Guinea in the drier or seasonally dry parts of the country. They carried with them their grazing domestic animals but the impact of these remained small. Historical accounts of early plantation or settled agricultural development (see the series of papers in Denoon and Snowden 1981) give little indication of the existing vegetation on the alienated or settled land. No doubt some was garden land and much was already grassland, but much also was primary or re-growth forest. Allen (1981) refers to crops planted by the German New Guinea Company in land newly cleared from rainforest and there are anecdotal accounts of alienation for plantations of suitable land that was not in use because of land disputes between adjacent groups or because of fear of sorcery.

Europeans introduced the full range of their available livestock - cattle and buffalo, sheep and goats, pigs, poultry and equines. The availability and introduction of tropical breeds of cattle and sheep (Holmes *et al.* 1976) assisted the establishment of these species and goats clearly became adapted (Quartermain 1982). Initially the introduced grazing animals were solely associated with plantation developments, either as draught animals or grazed under coconuts to keep the vegetation clear as well as produce meat. The later development of large-scale cattle ranches and the concerted effort to establish small-holder cattle projects in the early 1970s (Densley *et al.* 1978) took place mainly in areas with existing grassland in the Markham-Ramu valleys, Central Province savannas, the Eastern Highlands and the Sepik plains.

It is not possible here to go into the rise and fall and subsequent stabilisation of the cattle industry. Suffice it to say that the total herd numbers peaked in 1976 at 153,200 and declined to 80,100 by 1991. Accurate recent figures are not available but there has probably been only a little change overall since 1991, but current numbers may have declined further to about 70,000 head. Sheep and goat numbers have grown over the last years but remain modest, perhaps 15-20 thousand of each species (Quartermain 2002), although there has never been a systematic count. These smaller grazing or browsing animals are kept in very small flocks utilising fallow or waste land. Their environmental impact is negligible. It has been estimated (see Table 8.1 of Levett and Bala 1995) that there are 445,635 ha of grazeable grassland out of a total grassland area of 550,097 ha. The current cattle herd would utilise about 128,000 ha only. The potentials for expansion are discussed later. While it could be concluded that grazing areas are under-utilised, especially on customary land, individual cattle projects may still be overstocked with the grassland subject to ongoing degradation.

Global Concerns

On a global scale there have been major concerns for many years over certain aspects of the environmental impact of livestock production systems. A major international study on livestock and the environment was recently commissioned by a consortium of agencies and governments (de Haan *et al.* 1997, Steinfeld *et al.* 1997) and this was followed up by an international conference (Nell 1998). The concerns were classified into three categories corresponding with grazing, mixed farming and industrial production systems. None of the concerns to do with the sustainability of pastoral systems - overgrazing, land degradation and desertification, deforestation for ranching and conflict with wildlife conservation - are of major relevance in Papua New Guinea. Likewise, problems of soil and water pollution resulting from waste disposal from intensive industrial production systems, mainly of pigs and poultry, are not yet of concern in Papua New Guinea and may not ever become serious since there are adequate technologies available for the safe disposal or utilisation of such wastes on the scales likely to be found appropriate. Wider concerns over the production of green-house gases, the transfer of nutrients from areas of feed production to those of high livestock concentration and losses of domestic animal genetic diversity are of relevance in Papua New Guinea but there are no immediate problems that should or can be addressed.

Concerns associated with mixed farming systems are however of immediate relevance in Papua New Guinea. Most farming in the world is carried out in mixed crop - livestock systems, covering 2.5 billion ha of land and producing 54 percent of the world's meat and 90 per cent of the milk. Over the last decade, the growth in meat production from these systems has been about two percent per year which is below the likely growth in demand for meat at about three percent per year. Resource use in the systems is often required to be self-sustaining as nutrients and energy flow back and forth between crops and livestock. This flow is mainly comprised of crop residues or surpluses and animal manures or draught animal power. While most farming systems in Papua New Guinea are not integrated in this way or to this degree, the concerns are the same. These concerns arise from increasing difficulty for a system to meet the demands for productivity being made and to cope with the resultant

nutrient depletion. This becomes particularly serious when cropping is expanded at the expense of livestock with the resultant losses in the benefits of mixed farming detailed below.

Pressures on Papua New Guinea Cropping Systems

Most traditional Papua New Guinea crop production systems rely on long fallow periods to restore and maintain soil fertility and soil structure and reduce the levels of pests and diseases. Typically and ideally for food crops a piece of land is cleared and cropped for one to three years before the vegetation is allowed to revert, preferably to rainforest, for periods up to or in excess of 20 years. It is not the purpose of this paper to go into detail concerning the incredible variety of systems which exist currently in Papua New Guinea. The Agricultural Systems Project has identified, mapped and described a total of 287 systems, published in a series of working papers covering all 19 provinces. The basic methodology and text summaries for the systems are given in two volumes by Bourke *et al.* (1998). What is important here is that the traditional systems have come to a greater or lesser extent under pressure and have been modified to cope. (Allen et al. 1995; Bourke and Allen 1995, Levett and Bala 1995, Vasey 1981, Wood and Humphreys 1982).

The main pressures can be summarised as follows -

1. Population increase - agriculture is supporting some 80 percent of the population which is doubling approximately every 30 years. This pressure is only minimally mitigated by rural to urban migration.

2. Alienation of land for cash cropping - mainly plantation mode tree crops. This has been an ongoing process since European colonisation. There are also social problems and gardening on unsuitable land caused by increasing distances between village settlements and food gardens due to the establishment of plantation type agricultural activities (coffee and cattle projects) near to village residences (Grossman 1984).

3. Keeping up with the Jones - the so-called Jones Effect (Watson 1997) - which attempted to explain social and production changes following the introduction of sweet potato but has its modern counterpart in increasing demand or desire for the products of an affluent society, including greater meat consumption.

Responses to the Pressures

Papua New Guinea farmers have responded to these pressures in a number of ways which can be summarised as follows –

1. Expansion onto previously unused (for agriculture) land as a result of reduction in inter-group hostility or the introduction of new technology. However, note the previously mentioned conversion of these lands for plantation cropping and also that most unused or lightly used land is unsuitable for agriculture because of excessive rainfall, inundation or steep slopes. The extent of the unused land can be clearly seen in the map of land use intensity (Figure 1).

2. Widespread replacement of traditional crops, particularly taro, by more productive or adaptable introductions including sweet potato, cassava, chinese taro (Xanthosoma), potato, maize and peanut.

3. Replacement of existing cultivars by more productive or adaptable cultivars.

4. Longer sequences of cropping before going into the fallow, often with the addition of a new crop to the sequence.

5. Shorter fallow periods with a resultant increase in the extent of grass rather than woody fallows. This is particularly serious in the lowlands where grass fallows appear less effective in fertility restoration than in the highlands.

6. Inovative technologies - a number of techniques are used by Papua New Guinea farmers to help maintain soil fertility in the face of intensification of land use. These include short fallows of two to 12 months between crops in the sequence; complete tillage; mounding; making of beds; mulching; composting; planted tree fallows (particularly Casuarina); legume rotations (peanut, winged beans); animal manure (see below); placing of pigs in gardens (see below); burning; and soil retention barriers.

Of major concern are the longer cropping sequences and shorter fallows. The ratio of cropping period to total cycle length is a measure of land use intensity used in the Agricultural Systems Project, the R value following Ruthenburg (1976). R value classes have been mapped (Figure 1) to indicate where in Papua New Guinea farmers have needed or been able to intensify production. Bougainville, the northern Gazelle Peninsula and the central highland valleys stand out.

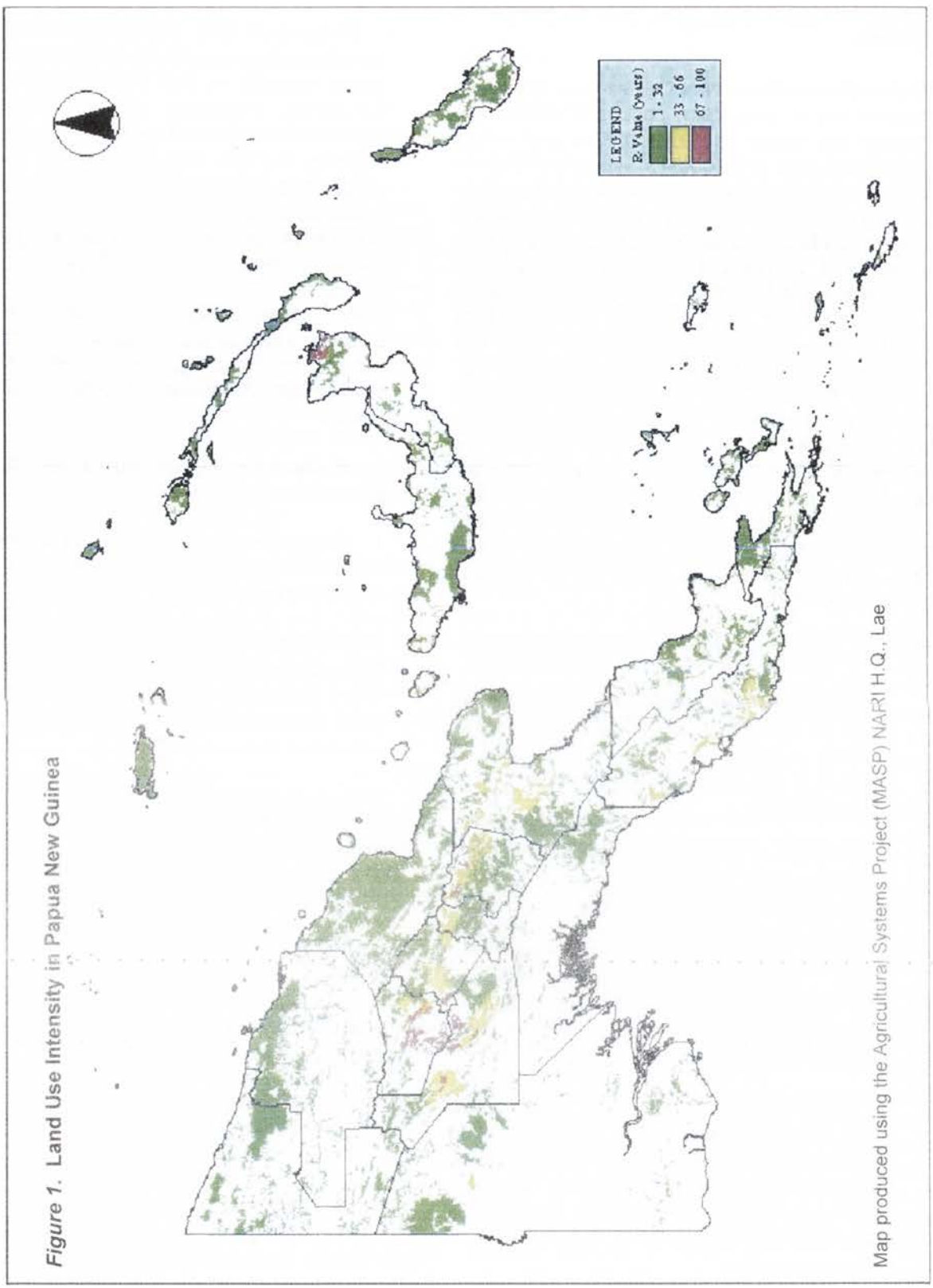

Figure 1. Land Use Intensity in Papua New Guinea

Roles for Livestock

It is necessary now to return to the main theme of this paper and discuss the role of livestock production in mitigating the adverse effects of intensified cropping. Quartermain (1975) produced a general account of roles for animals in food crop production systems in which he discussed the use of manures, crop residues, fallows and night pens, and the use of animals for weed control and as power units. Livestock make the best use of crop residues, by-products, wastes and surpluses compared to the alternatives of burning or direct incorporation into the soil. In mixed systems they can supply a high proportion of the soil nutrients required to sustain cropping through the use of manure either deliberately or from animals grazing or browsing on crop land between crops or in fallows. Manure improves soil structure through the addition of organic matter which may also be beneficial in maintaining the health and bio-diversity of soil micro-flora and fauna (de Haan *et al.* 1997). Animal manure increases the nutrient retention or cation exchange capacity of the soil and improves its physical condition, water holding capacity, structural stability and organic matter content.

In many systems in Papua New Guinea, pigs are allowed to forage in the fallows. The benefits or otherwise of this with respect to the fertility restoring role of the fallow are not clear. Pigs certainly have a sanitation role in consuming diseased un-harvested plant material and a range of garden pests. Rappaport (1968) describes how the Tsembaga people use pigs to benefit the secondary forest that is developing on abandoned garden sites by uprooting much of the herbaceous component and thinning the arboreal component. Rooting eliminates weeds and seedling trees, softens the ground and makes nutrients more readily available if the site is to be re-used for the next crop in the sequence. Some groups of people (including the Tsembaga and other Maring speaking peoples) practice the deliberate placing of pigs in gardens between crops during the cropping sequence. This practice has been mapped by the Agricultural Systems Project and a map showing the systems in which the practice was recorded is given as Figure 2. Peoples for whom this is significant include the Goilala, Anga, northern Simbu, Maring, southern Enga and the Huli.

The only other system in Papua New Guinea in which livestock are integrated with cropping is the grazing of cattle in coconut plantations. There are some 265,000 ha of coconut plantings in Papua New Guinea but about 40 percent of this is inter-planted with cocoa (Nevenimo 1989). Locations without intercropping tend to be those with poorer soils or a climate unsuited to cocoa such as in much of Central, Morobe and Milne Bay Provinces. Nevertheless, grazing under coconuts may remain or can be made economically viable with the advantages of reduced understory maintenance costs, higher nut recovery and a more efficient re-cycling of nutrients. However, currently probably less than 10 percent of the national cattle herd is grazed under coconuts.

Research work in Papua New Guinea has unequivocally demonstrated the benefits of the use of animal manures for crop production. A bibliography of published work is given in Appendix 1. It is probably unnecessary to do any more work to further demonstrate the obvious benefits. What is needed is consideration of how to use the limited material likely to be available in the most effective manner with the least cost in handling. Nutrient balance in a system (essentially the balance of gains and losses of N, P and K) is the over-riding crucial factor in determining the environmental impact of that system (Blackburn 1998). While mixed farming does not generate nutrients, except through the fixation of N by planted legumes, it does allow for nutrient transfers both spatial and temporal from one part of a system to another, accelerates nutrient turn-over and reduces nutrient losses. Mixed farming allows the use of waste products from one sector as inputs to another sector, e.g. by-products and manure.

Future Developments in Livestock Production

It is timely to give consideration to likely future developments in livestock production, giving attention to the mitigation of any possible adverse environmental effects and capturing the benefits of mixed farming. The integration of crops and livestock may be the only way to achieve or sustain intensification of food production and satisfy the demand for meat which might be expected to continue to grow at a rate of at least five percent per year commensurate with a population growth rate of 2.0 - 2.5 percent and anticipated increases in affluence. Mixed farming diversifies risk, uses labor more efficiently, generates increased cash income and adds value to low value or surplus feed. The environmental benefits could include the maintenance of soil fertility, replenishment of soil nutrients, possible reduction in erosion and reduced pressure to shorten the fallow period. The utilisation of the fallow by livestock can add value to the system and help justify the maintenance of a mosaic of vegetation types including multi-purpose tree species (MPTS) and edible soil retention barriers. Livestock can help prevent the collapse of intensive or intensifying cropping systems.

Research and development is now required to determine the best ways of achieving the benefits of mixed farming. Little need be said in this context

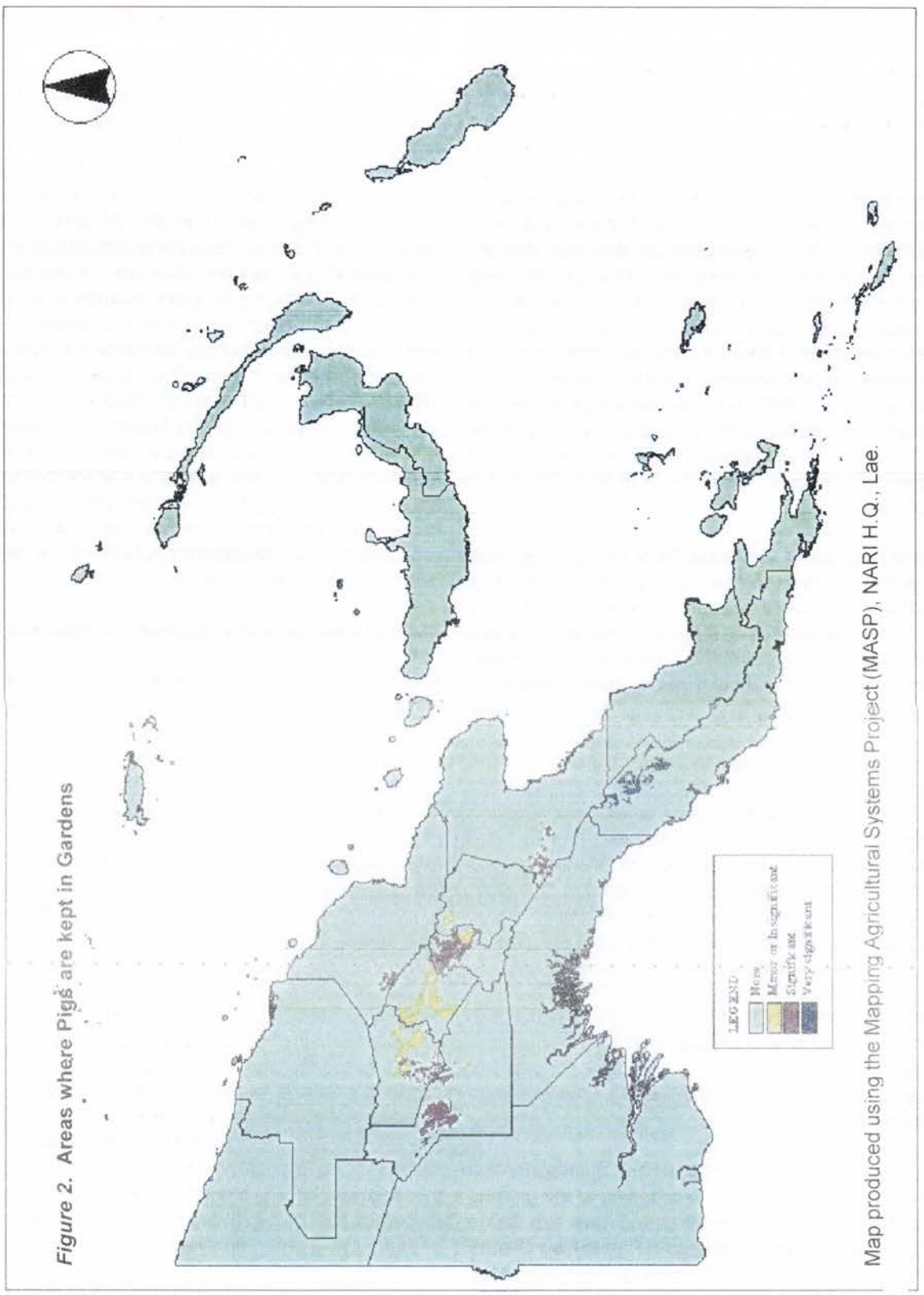

Figure 2. Areas where Pigs are kept in Gardens

regarding the intensive production of pig meat and poultry products except that the production systems must make maximum use of the available crop by-products, that local small-scale production is more likely to result in manure being used on gardens than larger-scale intensive peri-urban production and that one-way transfer of nutrients from arable feed grain, grain legume or root crop production areas to areas of livestock concentration is avoided as far as possible. The household production of meat from the smaller domestic animals such as rabbits, ducks and chickens can result in utilisable manure, but only from the poultry species if suitable night-housing systems are adopted. Sheep and goats are the species of choice for more intensive utilisation of waste lands and fallows. As indicated, pressure to reduce the fallow length can be mitigated if livestock can make economic use of this phase in the cycle, especially where grass fallows are now the norm. Fallows can be improved for livestock use through the planting of MPTS or the sowing of grazeable legumes. Research has been and is being done in Papua New Guinea on MPTS, including species suitable for livestock feeding. The situation as in 1992 and proposals for on-going work were reviewed by the Forest Research Institute (Nir and Srivastava 1992) and by Brook (1992). Research work is on-going in the National Agricultural Research Institute and the Papua New Guinea University of Technology.

There remains the need to consider further expansion of cattle production from natural grasslands (albeit anthropogenic) or sown pastures. It is most unlikely that primary forest would be clear felled for the establishment of cattle ranches. Any use of forest land for agriculture would be for the establishment of tree crop plantations. Due to a general shortage of good agricultural land not already in the garden cycle, any future development is likely to be crop oriented. However, as mentioned earlier, the estimated 445,000 ha of grazeable grassland is under-utilised and the theoretical national herd could be increased to some 300,000 head. In addition to the open grassland, there are up to 150,000 ha of coconut plantation not under-planted with cocoa, some 26,000 ha of smallholder oil palm and 22,000 ha of rubber which could be considered for sheep and goat production if not for cattle. The establishment of sown pastures in the near future may be restricted to the Markham-Ramu valleys where there may be some 60,000 ha of grassland still available for development. Overall growth in cattle production is constrained by, above all, accessibility to markets and long-term land tenure. Social inequalities and other problems caused by the establishment of cattle projects on grass fallow land have already been mentioned and are discussed fully by Grossman (1984) for a specific Eastern Highlands situation. Other constraints to pasture development include high interest rates, short lending terms and low returns on capital investment.

The grazing of natural grasslands should not cause any environmental problems provided that stocking rates are controlled to levels that allow the maintenance of good grass cover and prevent weed invasion. The sustainability of pastoral systems in Papua New Guinea is almost entirely a function of stocking rate and intensification of production should be undertaken using by-products (e.g. palm kernel meal) as supplementary feeds while maintaining low stocking rates. Details of such production systems cannot be discussed further here but clearly the location of sources of supplementary feeds is another constraining factor for cattle production. Avoidance of the use of alpine grasslands and those on steep slopes should help the maintenance of bio-diversity and indigenous grassland eco-systems.

Finally there are potential benefits to the environment from the promotion of livestock production not previously mentioned. Increased animal production could reduce pressure on hunted game in a reversal of the historical process in which reduced returns from hunting were an encouragement to domestic animal production. The promotion of the use of MPTS could reduce the pressure on the forest for firewood while the use of animal manures and research into biological control measures for weeds, pests and diseases should reduce pressures to use artificial fertilisers and agri-chemicals. The further development of livestock production should be undertaken with the maximum possible degree of local-level participatory planning to ensure the likelyhood of harmony with the total environment.

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APPENDIX 1

REFERENCES ON THE USE OF ANIMAL MANURE ON FOOD CROPS PAPUA NEW GUINEA

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