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1. EXECUTIVE SUMMARY

The objective of the Public Lands Utilization Study (PLUS) was to provide biophysical data and social information on the status and use of publicly held lands. This information was to be provided to assist decision making within Malawi's land policy reform programme.

For the purposes of this study, "public lands" were defined as *protected areas* (forest reserves, national parks, and wildlife reserves). However, spatial information was gathered on *agricultural schemes* occupying government land as well. The final products of PLUS include this report and a spatial, digital atlas; combined, these provide access to the information collected, the analyses of the data, and recommendations for policy makers.

PLUS was conducted in conjunction with utilization studies on Malawi's two other major land tenure types: estate land (ELUS) and customary land (CLUS). Completed in June 1997 and February 1998, respectively, these studies shared with PLUS the common purpose of improving the base of information on land in Malawi. The studies ran parallel to the activities of the Land Policy Reform Commission (LRCP), appointed by the President as an independent body to assess public views on land issues and make land policy reform recommendations to the government. This combination of efforts affords policy makers the opportunity to assess public land policy within a broader land reform programme. The most consequential conclusion reached by PLUS suggests that changes in public land policy should not be made in isolation, but within a general land policy concurrently addressing public, estate, customary, and urban land.

1.1 Approach

The Lands Steering Committee requested that PLUS determine:

- the location, distribution, size, and rationale for protection of Malawi's protected areas,
- the agricultural suitability, erosion hazard, population pressure and impact on these areas,
- the resource use patterns by neighboring populations,
- the role these populations play in local economies,
- the location, size, purpose, and current status of Malawi's agricultural schemes, and,
- an analytical framework for site-specific tenure change decisions.

PLUS addressed these objectives on two levels. Data were captured for all of Malawi's protected areas at the highest spatial scale possible (Level 1). In many instances the resolution of digital, national-level mapping data is currently not high enough to assess factors surrounding land use or the potential impacts associated with changes in land tenure. This necessitated a second analysis (Level 2) that integrated finer resolution spatial information with field-intensive site studies on selected tracts of public land and their adjacent communities. This focus permitted direct input from the Lands Steering Committee on site selection and emphasized the unique conditions of each protected area while permitting interpretations not possible at lower resolutions.

This approach differed from the global sampling strategy and the "efficiency of use" focus of ELUS and CLUS for several related reasons:

1. "Public Lands," with the notable exception of agricultural schemes, are judged to be unique. They were created to protect forest, water, and wildlife resources from the intensive use that would degrade or transform them. They exhibit great variety in inherent resources and in how those resources are used.
2. Changes in the allocation of Customary or Estate Lands would result in changes in tenure, and not necessarily changes in land use. Criteria for evaluating proposed changes might include consideration of efficiency or equity. With the exception of agricultural schemes, changes in the status of Public Lands involve changes in land use as well as tenure. Thus, evaluation criteria such as efficiency cannot be invoked without an understanding of the value of current uses.
3. If each reserve is unique in terms of its resource and value, then a "global" approach to evaluating them is not appropriate. Each public land must be evaluated in terms of the nature of its resource and the local environmental, economic, and social context in which it exists.

1.2 Summary of Results

On the national level, PLUS found that protected areas (forest reserves, national parks, and wildlife reserves) represent 20% of Malawi's land area and serve a variety of functions, though catchment protection was critical for over 80% of this land. They also serve as the stock for over half the country's woody resources. This is extremely important in Malawi, where fuelwood and charcoal represent the energy source for 98% of rural and 94% of urban fuel needs.

PLUS estimates that less than 10% of the land within protected areas is suitable for agriculture at an acceptable overall risk of erosion, though the study was constrained by low-resolution data for national soils, elevation, and slope. Population pressure on public land was greatest in the south and central regions, with population densities of almost 100 people per km^2 in the 1987 census.

Population pressure in the northern region was much lower (1987 census estimates of 35 people/km^2), though concentrations of around specific protected areas was very high. Projected population growth rates (3.2%) suggest that that the extreme theoretical case of immediately opening all of Malawi's protected public land—regardless of suitability—would provide additional land for only 20 years, at the current average land holding size per family (1.0 hectares), with all other contributing factors remaining constant (population growth, yields, etc.).

Estimates indicate that forest decline in Malawi is progress at a rate of 3.5% per year. The results of change detection analysis on data provided by the Forestry Department indicate that between 1973 and 1991, 6% of the land in protected areas has experienced negative change.

The five protected areas ultimately selected for Level 2 analyses were Mulanje, Zomba-Malosa, and Dzalanyama Forest Reserves, Liwonde National Park, and Vwaza Wildlife Reserve. These proved to be quite different from one another in terms of primary and secondary use, agricultural suitability, erosion hazard, population pressure, ease of access, and change in land cover between 1984 and 1994. Suitability for agriculture ranged from less than 3% of the land area in Mulanje to 63% for Vwaza and 90% in Dzalanyama. After erosion hazard analysis results were incorporated to determine the risk of soil loss under traditional agricultural management practices, only 58% of Vwaza and 51% of Dzalanyama proved to be *environmentally* suitable.

Population pressure analysis of the five sites followed the national trends, ranging from very high around Mulanje in the southern region (25 people per hectare of protected land) to much lower around Vwaza in the northern region (less than 2 people per hectare of protected area). In national terms, this suggests that 19% of Mulanje's land area is under pressure above the national average for protected areas while none land within Vwaza is under pressure in excess of the mean. The zones of higher pressure in a number of cases corresponded to concentrations of land cover change between 1984 and 1994 along protected area boundaries, though some areas under pressure were converted to forestry plantations during that period in Mulanje and Dzalanyama.

The range of figures presented above can be misleading if taken out of context. For example, Dzalanyama's high level of "environmentally suitable" land addresses two factors of suitability: potential for crop growth and erosion hazard. Yet the rationale for protecting Dzalanyama Forest Reserve is based on other issues such as protecting over 30% of the Lilongwe water supply catchment area and an even greater percentage of the actual drinking water. Similarly, Vwaza and Liwonde provide habitat to fauna, which are irreplaceable and critical to the tourism industry, which is an important source of Malawi's foreign currency.

Potential population pressure must also be considered in conjunction with these other factors. For example, lower population pressure near Vwaza does not necessarily mean lower demand for land. The advent of numerous tobacco estates has effectively decreased customary land availability to the point that there are limited land allocation options for local chiefs. This is a situation analogous to that faced in areas of much higher population density.

To introduce that important human component into the PLUS effort, a community-based study was carried out among the populations that abut the five protected areas. Following a multi-dimensional research methodology, a team of U.S. and Malawian researchers conducted rapid appraisals in 138 communities around the reserves, then designed and implemented a formal survey in 22 villages, interviewing over 550 households.

This component of the research addressed three fundamental questions: what is the socio-economic profile of the households surrounding the protected areas; what resources do they extract from the reserves and in what quantities; and what is the impact of reserve utilization on the well being of these households. With these goals in mind, the study identified the sources of income that make up the livelihood systems of these communities, quantified household income, then estimated poverty levels using a national per capita maize dietary standard as a proxy measure of the barest minimum level of survival.

The results unambiguously demonstrate the precarious livelihoods of the households in the study. Overall, nearly half the entire sample cannot meet the basic maize-based standard. The major factor determining this level of poverty is the lack of adequate agricultural land as well as the absence of non-agricultural employment opportunities. In those protected areas where the surrounding population pressure is highest and the land more scarce, poverty is clearly more extensive.

At the same time, the annual (1996) use of reserve resources was quantified for each household and expressed in terms of kilograms per capita. This estimate was then compared against a national measure based on per capita wood consumption (adjusted for non-wood resources). In this case, the majority of the population is situated well above the proxy standard, suggesting intensive use of the resource base. A distinction between household utilization and income-generating activities based on protected area resources as either inputs or outputs demonstrated that almost half the households not only consumed products from the reserves, but also gained income from this utilization.

To answer the third question, an estimate of the importance of reserve-based income was derived, and it demonstrated that the protected areas indirectly generated about one third of the total household income for those families using the resource. In effect, the community-based study clearly indicates that the income-earning potential from proximity to the protected areas makes a critical contribution to livelihood survival. At the same time, the local population resents the closure of the protected areas and the transaction costs associated with extraction. They expressed a clear desire for access to the agricultural lands within the boundaries, even though such access might easily compromise the natural resource endowment of the reserves.

These results provide an information base for decision-makers, but also highlight the fact that every decision is site-specific. In each case, site-specific expertise will be required to evaluate the available information while local representation of all interested parties will be paramount in reaching the consensus on tenure and management necessary for successful implementation.

2. RECOMMENDATIONS

The following recommendations represent a synthesis of data analysis, model results, and opinions expressed in surveyed villages as well as those from the debate on issues which took place during the PLUS Closing Seminar in November 1997. In cases where the individual views expressed in the field or during the debate did not reach consensus, we have attempted to include the differing perspectives. This effort to combine quantitative data analyses with qualitative perspectives underscored the quintessential need for decisions on changes in land tenure to be made by qualified representatives of all local and national stakeholders. Decisions made on study results alone will not incorporate the unique views of those who will ultimately be directly impacted. These recommendations and indeed the entire analysis of PLUS, have been greatly enhanced by national expertise provided by the Lands Steering Committee and by the local participation we received throughout Malawi.

1. *Land policy reform and tenure change decisions should not be made in isolation, but rather as part of a general land policy framework, which considers the interactions between public, estate, customary, and urban land concurrently.*

   All three utilization studies demonstrated the inter-dependence and conflict among sectors (public, estate, customary, and urban). Security of tenure, availability and access to resources and the potential to find alternatives to land-dependent income strategies are three examples of inter-dependence that cross tenure boundaries. A change in policy for one tenure type will impact each of the others. This necessitates a coordinated policy representing all stakeholders with mechanisms to address potential future changes in land tenure or use in an equally coordinated and representative fashion.

2. *It is unlikely that long term solutions to land shortages in Malawi will prove to be land-based; alternative income sources for members of smallholder families could ease the demand for land.*

   Land demand estimates suggest that converting “available suitable” land to agriculture from all sectors will provide at most, 20 years worth of land given current crop yields and population growth trends (and assuming a mean land holding size of 1.0 hectares per family). Increases in agricultural productivity or the prospect of agricultural expansion into marginal lands through the adoption of improved management techniques have resulted in limited increases in agricultural productivity during the past 15 years. Smallholder families, faced with shrinking per capita land holdings, require alternative income sources beyond their personal farms to meet the needs of their children in the future. PLUS socio-economic analyses showed that families faced with land shortages actually use public land resources to generate additional income (i.e. fuelwood, brooms, fruits, medicines, timber, charcoal, etc.).

3. *The protected status of Malawi's parks and reserves should not be considered for degazettement prior to obtaining further understanding of the "available, suitable" land in the customary sector.*

   To put this in perspective, note that public land (including agricultural schemes) represents 2.0 million hectares, or 21% of Malawi's land area, while suitable customary land represents 4.3 million hectares, or 44%. CLUS II has found that 1.9 million hectares of customary land are currently under cultivation (including 266,000 ha unsuitable for agriculture), leaving 2.6 million suitable hectares theoretically "available" for cultivation – 1.3 times the total land in the public sector. It has been suggested that much of that "available" suitable customary land may be occupied by dwellings, urban expansion, and/or undocumented estates. Other portions may not yet be exploited due to limited access to drinking water, or they may be considered "long term fallow" due to loss of soil fertility in the past.

   PLUS estimates that only 10% of the protected area land may be suitable for agriculture and even the most favorable estimates do not exceed 30%. Yet protected areas represent over half of Malawi's national stock of natural resources, representing a major source of fuelwood. They serve other critical needs: protecting catchments to limit soil erosion, maintaining stable sources of drinking water (particularly for urban areas) and providing habitat for Malawi's unique wildlife.

   If 100% of Malawi's protected areas (regardless of suitability for agriculture) were converted to agriculture, land demand estimates suggest population growth would exceed the expanded land base in less than 20 years. If such a change were made, valuable and often irreplaceable ecological resources would be lost and any recovery efforts would be costly and would take a considerable amount of time, if they were even possible. Topsoil losses and nutrient depletion are very difficult processes to reverse.

4. *Each protected area in Malawi is unique – requests for change in tenure should be considered on a case by case basis with involvement of all stakeholders at the local and national levels.*

   PLUS findings at the national level as well as for the five intensively studied reserves demonstrate how variable protected areas are in terms of their use and biophysical conditions, as well as population and political pressures. The framework for decision making provided by PLUS offers a suggested response mechanism to requests for change in tenure status of a given tract of land. Without question, some of the steps require time and resources, yet each step provides critical information that is needed for an informed decision. Each step insures stakeholder participation at the local and national level so that all those affected are part of the process and are involved in the solution. This involves costs; however, these potential costs are not greater than the costs of permanently lost resources where a decision was made with limited participation or inadequate information.

   The demand for a blanket policy solution for all of Malawi's protected areas at one time is based on the current, intense pressures on these reserves and parks. For a solution to be viable, particularly at the local level, policy decisions must be made based on all information currently available and on the basis of consensus of all interested parties. The policy should include provisions for addressing requests for change in land tenure on a case by case basis that incorporates participation by all local stakeholders and multi-sectoral expertise at the national level.

One of the highlights of the PLUS Closing Seminar was an intense debate over the "best use" for Malawi's protected areas. The debate was heated, particularly in the beginning when opposing viewpoints supporting agricultural expansion and more stringent protection were raised. However, as the debate evolved, examples related to specific reserves or parks were put forward, and with each, information unique to the local situation had to be interjected in order to inform the discussion. It became clear that the choice between agriculture and protection was not the same for any of the examples. Moreover, those able to contribute to the discussion on a given example varied, either because they had local experience, or had expertise involved directly with a local issue (such as drinking water supply or plantation management). During the presentation it was very clear that the extensive data collected for Mulanje, Zomba-Malosa, and Dzalanyama Forest Reserves, Liwonde National Park, and Vwaza Wildlife Reserve served as a foundation from which discussions among stakeholders – some with conflicting views – could begin to form decisions in a collaborative manner. The information informs the debate and allows it to be connected directly to the land, but should not—in isolation of stakeholders—direct policy or tenure decisions.

5. *The theoretical case of opening public lands to cultivation would necessitate translocation/resettlement exercises, as there are striking geographic differences in the locations of protected areas (the supply) and in the concentrations of high population density (the demand).*

   On the national level, PLUS has found that potential population pressure relative to proximity to public lands is highly variable. This is true not only between regions, but within them as well. Moreover, there is high variability in the total land area of each protected area and the corresponding population density. If the objective of opening up land to cultivation is to at least temporarily alleviate pressure for land, the costs of resettlement that may be required to move those in need of land must be included in the analysis.

6. *Protection of public lands represents the inferred lost opportunity to open land to cultivation. This cost to local communities should be compensated through benefits derived from protection.*

   Families adjacent to protected areas are faced with a quandary. They need land and that which is inside the protected area appears available. However, they also require the resources they obtain from that land, both for basic sustenance (fuel, medicine, hungry season foods, and sometimes even water) and for alternative income (they represent 30% of household income). Faced with a choice, most families would take the land over the resources, though with regret. A viable alternative would be a co-management situation where inhabitants of communities adjacent to protected areas could sustainably utilize reserve resources as well as a portion of the income generated by the official primary use, such as tourism or timber sales. The strategy would have to emphasize the importance of not letting incursions beyond sustainable use go unchecked by using access to proceeds from the protected area as an incentive. If the net benefit of such an arrangement exceeded the costs represented by their limited access to the protected land (i.e. foregone agriculture production or resource sales), the potential for success would be greater. If the costs of such an arrangement exceed potential income from the reserve and protection is still desired, other methods of compensation should be considered.

7. *A balance between strict protection (i.e. policing) and open access to public land and resources can be found in Community-Based Natural Resource Management.*

   PLUS did not study management strategies on Malawi's public lands. However, in virtually every village meeting and in most of the key respondent interviews, concerns were raised about the impacts of protection conducted solely through the policing by forest guards and scouts. The objectives behind the policing were generally understood and respected, but the need for resources and in some cases even land was viewed as great enough to warrant breaking the law. On the other hand, free access was also viewed as negative, particularly where over-exploitation of resources was already evident.

   The desire to cooperate in protection efforts was much greater where line agency personnel had shifted from strict policing efforts to a combination of extension and enforcement, particularly in conjunction with a Community-Based Natural Resource Management (CBNRM) program. Sharing access to, and benefits from, the resources encouraged participation in self-regulation of extraction. In Vwaza Wildlife Reserve, PLUS had the opportunity to compare attitudes in villages involved with a pilot CBNRM program to those from villages not yet involved. The greater the stake local communities had in the reserve and its proceeds, the more willing they were to establish self-enforcement and the better their attitudes were towards the agency responsible for protection.

8. *Two major areas of policy and legislation must be reevaluated with respect to land and natural resources in order to resolve inherent conflicts: codified vs. customary land law, and traditional cultivation/resource management practices vs. pressures from the international market.*

   Participants at the PLUS Closing Seminar raised the concern that current land policy and legislation did not incorporate traditional customary law and practices well enough to address current pressure for land, particularly within protected areas. Protected areas, as is the case for customary land, are often considered the land of all Malawians, and yet management and rules of access to protected areas are not currently an official part of the customary system of land allocation and management. While it was generally accepted that protected areas required different management, the general consensus was that excluding them from the customary system of land management enhanced the potential for conflict and reduced the chances for sustainable use.

In addition, it was also suggested that new strategies in natural resource management might fail if they were not developed in conjunction with agricultural policy. Particular examples given included efforts to promote burley tobacco production and the manipulation of input subsidies such as fertilizer prices without consideration of environmental or economic impacts, particularly in the long term. International market pressures were viewed by some as having the direct effect of boosting income, particular for medium income-level smallholders. However it also was suggested that it may have the indirect affect of increasing vulnerability at the household level (particularly among lower income smallholders) when those pressures encouraged cash crop rather than food crop cultivation.

Abrupt and substantial changes in subsidies for fertilizer left some families with soils depleted of organic-based nutrients due to previously promoted inorganic chemical fertilizers. These families were faced with inadequate income to cover the new costs due to decreased subsidies and virtually no transition time to return to green tillage and manure applications, strategies pursued in the past but which require several seasons to revitalize nutrient-depleted soils. These conflicts put further pressure on protected areas as a source of resources (i.e. poles for tobacco drying sheds, etc.) for cash crop production as well as sites for alternative land to those nutrient-depleted plots.

Participants also raised a word of caution: traditional land practices in the face of non-traditional population growth and changing market conditions do not lead to easy solutions, hence the recommendation that policy makers attempt to reconcile customary law and practices with contemporary conditions.

9. *Civic education in natural resource management should run in tandem with similar education for line agency personnel, all within a programme that links the benefits of sustainable resource management to those in need of the resources.*

Both representatives of communities adjacent to protected areas as well as participants at the PLUS Closing Seminar acknowledged that there is some history of local management of natural resources, but much time has passed since those days. In the intervening period, rural population has grown while land and resources have become more difficult to obtain. It was proposed that education in natural resource management was necessary to combine the local knowledge of the land and resources and management practices of the past with today’s social, economic and environmental conditions. But at the same time, concern over the need for a similar education programme for forestry guards and parks and wildlife scouts would be crucial. It was expressed that local communities possessed the knowledge and abilities to conduct natural resource management, if they could be given the capacity to do so and could work side by side with the line agency personnel attempting to achieve the same goals. Both local and national representatives cautioned that such an effort would not succeed unless the real and perceived benefits of sustainable natural resource management outweighed the costs to local communities.

10. *Malawi's government-owned Agricultural Schemes should be evaluated for privatization and/or conversion to customary tenure and/or management.*

    Malawi has more than 60 agricultural schemes, representing over 215,000 hectares of land. A number of these are being evaluated for privatization while others are being evaluated for the potential transfer of management to local cooperatives. Many are considered unproductive and a few are actually lying idle. Most schemes (other than some of the veterinary operations) lie on land suitable for agriculture and in many cases, are under cultivation or have been in the past. Their potential should be evaluated in the same manner as other government-owned entities that have been considered for privatization.

3. THE PROBLEM

3.1 Population

Protected land represents 20% of the total land area in Malawi, which is not an exceptional proportion in either in African or international terms. However, Malawi's population is over 87% rural and is growing at a rate of 3.2% per annum, which is high in international terms. While other countries in the region have similar overall growth, their rate of urbanization is much greater than Malawi's 13%: in 1992, Tanzania had 22% urbanization, Mozambique had 30%, and Botswana had 27%[1]. When comparing national population density to the total land area under protection, the level of pressure on Malawi's reserves and parks becomes quite evident (Table 1). In aggregate per capita terms, the area under protection exceeds that of any other African state.[2]

Table 1. Population density relative to protected government land.

Country	Portion of Total Land Protected* (%)	Population Density (1995) --(people/km²)--	Pressure on Protected Land --(people/km²)--
Malawi	20	106	532
Tanzania	25	27	106
Botswana	37	2	5
United States	17	27	157

*national protected areas (in the U.S., federal land)

Reductions in the overall population growth rate or increases in urbanization (particularly *planned* urbanization) may reduce the rate of increase in land demand, but they will not solve the problem. Moreover, urbanization that relieves pressure on rural land still leaves the demand for increases in urban land, though at a lower rate. Representatives of the National Statistics Office as well as UNFPA cautioned against revising the 3.2% estimated rate of population growth for variables such as potentially higher mortality relates linked to AIDS. While plausible, these often-cited scenarios will not be truly tested until after the current census and other factors that may negate or refute their affect on the growth rate.

3.2 Agricultural Productivity and Management

Most studies indicate that the mean land holding size for a family of five in rural Malawi was at or below 1.0 hectare in 1997, a poverty threshold often cited by aid organizations below which vulnerability increases substantially.[3] This is recurrently presented as a problem of land shortage, suggesting the need for re-assessment of the supply of land,

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[1] Aveco/BMB, 1995. Study On Local Authority Access to Development Land, Malawi. Ministry of Local Government, Lilongwe, p. 51.

[2] These figures were computed by relating total population to total protected land area. The comparison with the rest of Africa was drawn from Bell, R., H. Chikoko, H. Kamwendo, and K. Stevenson. 1997. Community based natural resource management: a strategy for the USAID NATURE Programme, Malawi.

[3] Johnson, J.1996. An Analysis of the Extent, Causes, and Effects of Food Insecurity in Malawi, with an Approach to Improving Food Security. FAO, Lilongwe.

and, as was the case during a number of the 1994 election campaigns, considerable political pressure for redistribution. However, other variables are critical to assessing the impact of land holding size on overall livelihood.

For example, the land problem can equally be assessed from the perspective of agricultural yield. Productivity figures from the Ministry of Agriculture and Irrigation reveal that agricultural productivity has not improved significantly in the past fifteen years, though despite two recent droughts the trend since 1994 is encouraging (Figure 1).

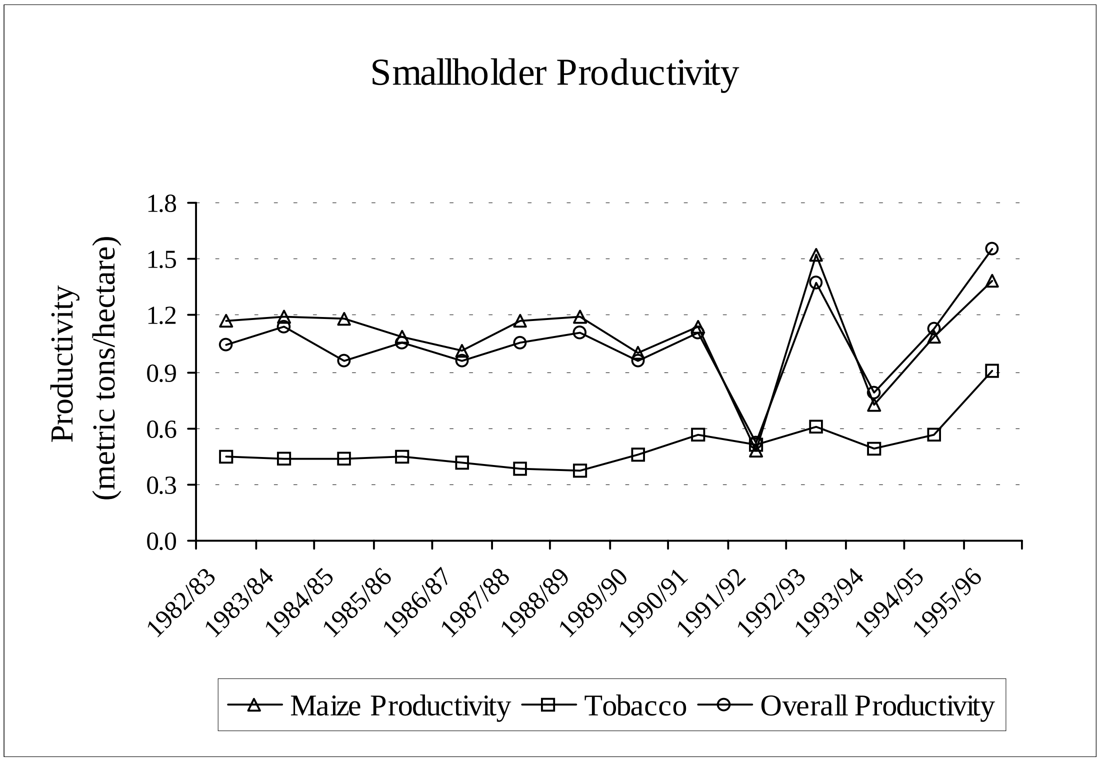

Figure 1. Smallholder productivity for maize, tobacco, and overall cultivation.[4]

Smallholder burley tobacco production has contributed to Malawi's agricultural growth and to household income (per capita incomes 70% higher than non-burley producers), but apparently has also impacted the viability of estate production, particularly estates greater than 40 hectares in size.[5] These increases tend to be identified with middle or upper income smallholders, but appear also to have put strain on maize production (burley replacing maize), particularly in lower income households, raising concerns about food security.

Another response to land pressure has been to open plots in marginal land. These attempts to extend the land base have met with limited success and contribute to topsoil loss due to erosion because traditional land management is not sufficient to make these areas suitable for cultivation. Moreover, the majority of smallholders have not adopted

[4] Data derived from Ministry of Agriculture and Irrigation estimates of land cropped and crop production.
[5] Steele, R. 1997. Farm Management Survey. ELUS, Lilongwe.

improved management techniques promoted by the Ministry that are designed to permit cultivation of land considered marginal under traditional management.

Current approaches in agricultural intensification focusing on improved land use, agroforestry, crop and livestock diversification, increased agricultural inputs, and sustainable rural credit are crucial components of the government's economic development strategy. All could contribute to reducing the overall land pressure in Malawi, particularly if they were integrated into national land and environmental policy.

3.3 The Land Balance

One of the fundamental objectives of the three utilization studies was to ascertain total land in Malawi for each respective tenure type (Table 2). For PLUS this meant digitizing protected area boundaries from 1:250,000 survey sheets (1:50,000 sheets were used for Level 2 sites), and obtaining and then digitizing sketch plans for the agricultural schemes. The problem was more complex for ELUS and CLUS due to land database and registration errors, and in both cases the total areas were derived from scaled-up samples. A recent study for the Ministry of Local Government provided figures for urban land.

Table 2. The Malawi land balance.

Tenure Type	Status	Land (ha)	Totals (ha)	Portion of Malawi's Land (%)
Public[6]				
Protected Areas	suitable	185,000		
	unsuitable	1,665,000		
Ag. Schemes[7]	mostly suitable	150,000	2,000,000	21%
Estate[8]	cultivated*	600,000		
	available, suitable	360,000		
	unsuitable, uncultivated	220,000	1,180,000	13%
Customary[9]	cultivated*	1,900,000		
	available, suitable	2,600,000		
	unsuitable, uncultivated	1,600,000	6,100,000	65%
Urban[10]	4 major cities	85,000		
	Other urban	35,000	120,000	1%
Total Land			9,400,000	

[6] Public land figures are derived from PLUS (1998); suitability of protected areas is based on FAO soils at 1:5,000,000 and 1 km digital elevation and slope data.
[7] Agricultural schemes were not evaluated digitally, though field observations by ADD staff indicate that most are on suitable land with the exception of some veterinary schemes. Dzalanyama Ranch occupies the same area as Dzalanyama Forest Reserve and thus is counted in the protected area figures only, to avoid duplication. Adding the Ranch to Agricultural Schemes would raise that total from 150,000 to 218,000 ha.
[8] Gossage, S.J. 1997. Land Use on the Tobacco Estates of Malawi. ELUS, Lilongwe, p. 23.
[9] BDPA, 1997. Summary of Main Findings of Customary Land Utilization Study. CLUS, Lilongwe, p. 4.
[10] Aveco/BMB, 1995. Study On Local Authority Access to Development Land, Malawi. Ministry of Local Government, Lilongwe, p. 51-105.

*the “cultivated” category includes 30,000 ha of unsuitable estate land and 266,000 ha of unsuitable customary land, respectively.

When all of these figures from different studies were combined, the grand total exceeded the total land area of Malawi by approximately one percent, primarily due to sampling error and potential misclassification between tenure types. The figures depicted in Table 2 were therefore rounded down to adjust for the imbalance.

All three studies used similar adaptations of Land Resources Evaluation Project (LREP) analysis guidelines for assessing agricultural suitability.[11] However, while CLUS and ELUS based their estimates on interpretation of aerial photography from 1994, PLUS brought the LREP “suitability factors” directly into a geographic information system (GIS) and conducted the analysis digitally. At the national level, PLUS had the disadvantage of having to use low-resolution soils, elevation and slope data—all critical inputs to the agricultural suitability assessment.[12] However, because PLUS had all of Malawi’s reserves and parks mapped digitally, the entire protected area sector was processed and mapped. In contrast, ELUS and CLUS used a representative statistical sample and then scaled up for national estimates of area. However, they were limited to the sampling area for all mapping.

The second phase of CLUS was faced with a considerable data reconciliation task—phase one estimates had put customary land under cultivation at over 3.3 million hectares, almost 75% more land than annual crop estimates and the findings of the National Survey Sample of Agriculture (NSSA) of 1991/92. That estimate suggested 1.2 million ha remained “available and suitable.” Both the NSSA and CLUS I sampling methods were repeated (through a sub-sample) and the figure of 1.9 million cultivated hectares was reached using both techniques, suggesting 2.6 million ha are “available and suitable.” The differences between these phase two results and those of CLUS phase one were put mostly to photogrammetric interpretation, particularly in areas where estate, urban, and customary land form a complex mosaic.[13] While the new cultivation figures agree more closely with annual crop estimates and the NSSA, they also imply that 43% of the customary sector is left uncultivated that is suitable for agriculture. At 2.6 million ha, this represents 28% of Malawi’s total land area.

CLUS researchers hypothesized that shifting cultivation (i.e. land left idle for extended periods due to poor soil fertility), dwellings, government buildings and grounds, and overlap between both estates and urban land together explain much of what had been

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[11] Green, R. and S. Nanthambwe. 1992. Land Resources Appraisal of the Agricultural Development Divisions: Methods and Use of Results. LREP Field Document No. 32; MOA/UNDP/FAO, DP/MLW/011, Lilongwe.

[12] The limited resolution of these data input layers makes utilization of the output map much less effective for analysis of specific protected areas than necessary for local decision making. For this reason, the LREP Soils and Physiography maps (1:250,000) were digitized for the Level 2 analysis, providing much more information at the protected area level. Eschweiler (1993) suggests an LREP analysis for all protected areas may reveal 600,000 ha of protected area land are suitable for agriculture. See “Summary of National Results” for further comment, and Chapter 5 for Level 2 suitability modeling. See Eschweiler, J. 1993. Malawi Land Use Issues. World Bank, Lilongwe/Kortenhoef.

[13] BDPA, 1997. Summary of Main Findings of Customary Land Utilization Study. CLUS, Lilongwe.

labeled "available and suitable." During the PLUS Closing Seminar, a number of participants suggested that lack of access to drinking water prevents expansion of agriculture into some areas otherwise suitable for agriculture, another potential explanation. At that seminar, clarification of the status of the 2.6 million hectares of "available, suitable" customary land was deemed a top priority necessary prior to development of land policy reform options. Clearly, changes in current tenure should not be made until the availability of suitable land in the customary sector is further understood.

3.4 Land Demand vs. Availability

The next logical step in assessing the problem is to combine land and population to plot land demand against availability over time (Figure 2). The graph on the following page is based on the following criteria and assumptions:

1. *Land Area:* Land areas are drawn from Table 1; the top-most line is the equivalent of all Malawian land (in all, 9.4 million ha). The lower third (urban, cultivated customary and estate land) accounts for all land already allocated and in use (including cultivation on unsuitable land). The middle tier includes all potentially "available, suitable" land in Malawi, including agricultural schemes and suitable protected area land. The top tier is made up of uncultivated, unsuitable land from all sectors.
2. *Population:* The land demand curve is based on population and population growth estimates for Malawi as a whole from 1901 through 1987,[14] and the use of NSO and UNFPA future growth estimates of 3.2% overall and 5.64% urban growth for all years thereafter.[15] Past urban rates were obtained from urban totals relative to total population since 1970;[16] years prior were based on a 5% increase per annum. Current estate population (those residing on estate land) was drawn from ELUS reports; totals from previous years were derived from historical descriptions, with the explosion of growth beginning in 1970 when estates went from 250 to over 30,000 by 1996.[17] An assumption was made that estate population growth would slow to 1% between 1996 and 2007, and then stop growing entirely. Customary land population was obtained by subtracting the urban and estate totals from the total population for each year.
3. *Land Demand:* The curve can be read as "hectares demanded relative to population." Population was then linked to land holding size in the customary sector, and total sector land for urban land and estates, using 1996 figures. For customary land there are many estimates available, which all agree at approximately 1.0 hectares per household. With the average household containing 5 people, the rate of land use was 0.20 hectares per person. For urban land, including all commercial and industrial areas, it came to 0.073 hectares per capita. Estates came to 1.323 hectares per capita. Land demand by year for each sector were added

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[14] Historical growth rates are drawn from Chipande, G. 1988. The impact of demographic changes on rural development in Malawi, in R. Lee, *et al* (eds.), Population, Food, and Rural Development, Oxford, Claredon Press, pp.166-174.

[15] Current and future rates are from NSO, 1994. Malawi Population and Housing Census 1987, Vol. VII Analytical Report. NSO, Zomba; and, UNFPA, 1996. UNFPA Country Programme Malawi. UNFPA, Lilongwe

[16] Urban figures came from Aveco/BMB, 1995. Study On Local Authority Access to Development Land, Malawi. Ministry of Local Government, Lilongwe.

[17] Estate estimates are derived from Bosworth, J., R. Steele, L. Mapemba. The Organization, Management and Population of Tobacco Estates in Malawi. ELUS, Lilongwe as well as ELUS, 1996. Land People and Production on the Estates of Malawi. ELUS, Lilongwe.

together to obtain the final overall land demand curve. As an aid towards interpretation, land demand (hectares per total population) is identified on the graph for 1990 and 2000.

4. *Other factors* (i.e. agricultural yield or access to alternative income sources outside of agriculture) are held constant to their impact on 1996 land use.

Figure 2. Land demand vs. availability.

Based on the criteria and assumptions stated earlier, several important inferences can be drawn from Figure 2:

1. The extreme hypothetical case of converting all public land, regardless of suitability, to agriculture today would permit only 20 years of land demand to be met, using the 3.2% population growth rate shown in Figure 2. Lower rates (2.6% is often cited) of population growth would extend this to 30 years.
2. If available, suitable, land in the estate and customary sector were to be converted first, it would be consumed by land demand in 30 years. Adding agricultural schemes and suitable protected area land would extend this by two more years.[18]
3. The land demand curve steepens sharply after 1970 and then levels off slightly after 1997 and 2007. The sharp increase in the demand rate is due to the dramatic expansion of estates. Though this has significantly slowed (due to the moratorium on estate creation), it still has the effect of increasing land demand because estate land supports fewer people per hectare than either urban or customary land. If estate land continues to grow (it is assumed to stop entirely by 2007 in this analysis due to enforcement of the government moratorium on estate creation), the land demand curve will become steeper. Conversely, more rapid urbanization (particularly if it is planned) could slow the rate of increase in land demand.
4. Other factors such as changes in agricultural productivity or a lower, overall population growth rate would affect the curve.

From the perspective of economic development, a more feasible scenario would be an increase in income alternatives to agriculture, thereby shifting a portion of Malawi's population out of land dependence through opportunities outside of cultivation.

3.5 Roots and Rationale for Protection

The departments of Forestry, Parks and Wildlife and Environmental Affairs all were instrumental in PLUS research on the history of protection in Malawi.[19] The data gathered were supplied to the Inter-Agency Working Group on Protected Areas which summarized the information and used it as part of a memorandum submitted to the Land Policy Reform Commission in July 1997.[20] The data were also added to the digital maps of Malawi's protected lands to permit spatial analysis of the historical creation and current rationale for today's protected areas. Much of the text and several of the diagrams in this section are drawn from those data and the research and analysis conducted by the

[18] If the Eschweiler (1993) estimate of 600,000 ha of suitable land in protected areas were used, all suitable land would be consumed by 2031, or 2 years later than the PLUS estimate.
[19] Primary sources for history and rationale included: Department of Forestry, 1993. A Register for Forest Reserves for Malawi. GOM, Lilongwe; and, DNPW, 1983. Principle Master Plan for National Parks and Wildlife Management. Lilongwe, Commonwealth Fund for Technical Cooperation. These data were updated by members of each department.
[20] Inter-Agency Working Group on Protected Areas. 1997. Protected Areas: Their Role and Future in Malawi's Land Budget. A Memorandum Submitted to the Presidential Commission of Inquiry on Land Policy Reform. Lilongwe.

departments and the Working Group (see Appendix A for summary information on each protected area).

The first instance of protecting land in Malawi from settlement and hunting occurred in 1897 when the Lake Chilwa and Elephant Marsh Game Reserves were created in order to preserve large game species. Within fifteen years protection was removed from both areas, but the process of protection had begun and would continue through the 1970s, interrupted only by two World Wars, the transition to Independence, and, ultimately, land pressure in the 1980s (Figures 3 and 4).

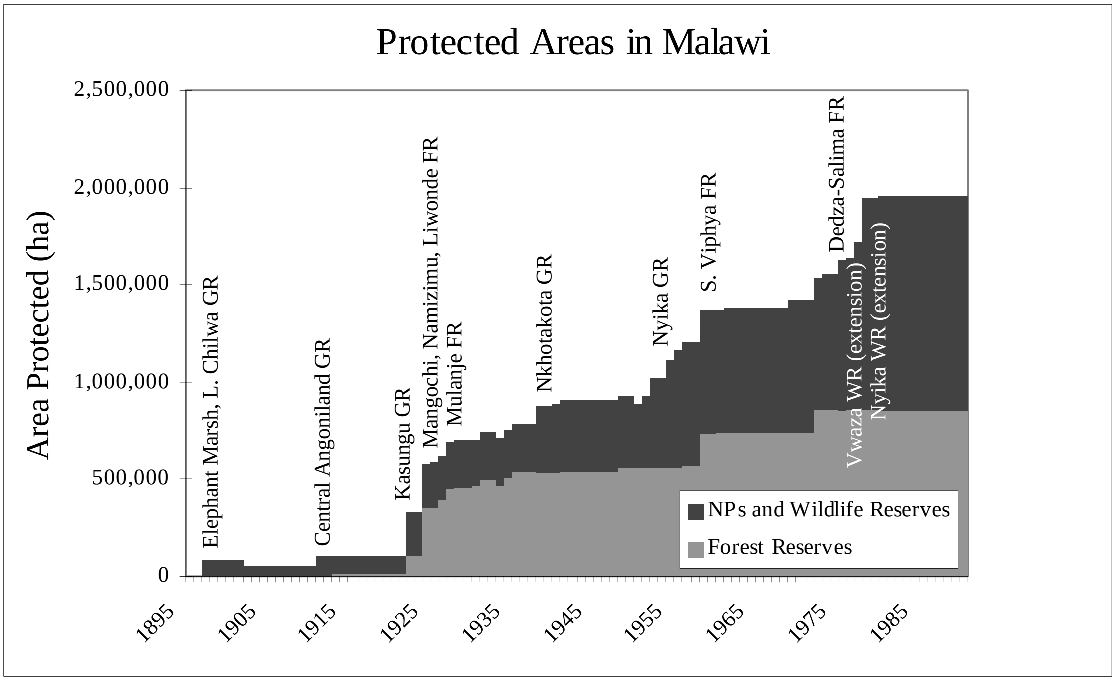

Figure 3. Historical increase in Malawi's protected area.

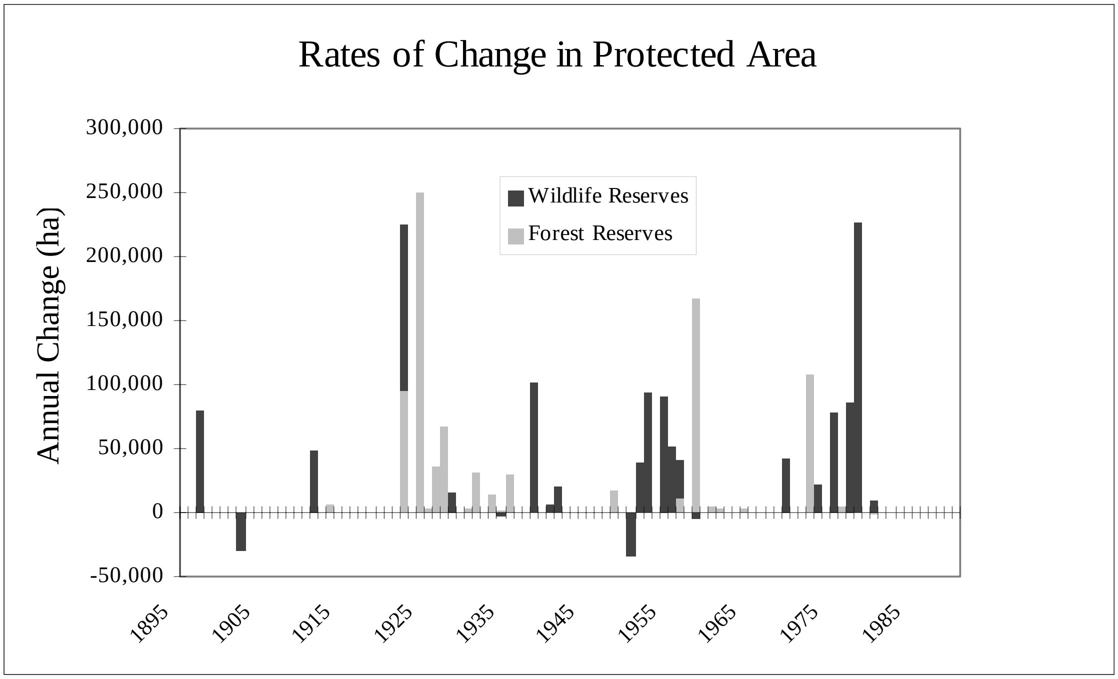

Figure 4. Rates of change in protected areas.

Most of Malawi's protected areas were gazetted before land pressure had become a serious issue, though the rate of expansion in public lands was comparable to population growth (Figure 5). Over 70% of the land eventually put under government protection was already gazetted prior to independence. The remaining 30% includes Nyika, Liwonde, and Lake Malawi National Parks, extensions on Lengwe and Vwaza Wildlife Reserves, the Dedza-Salima Forest Reserve, and a number of smaller forest reserves.

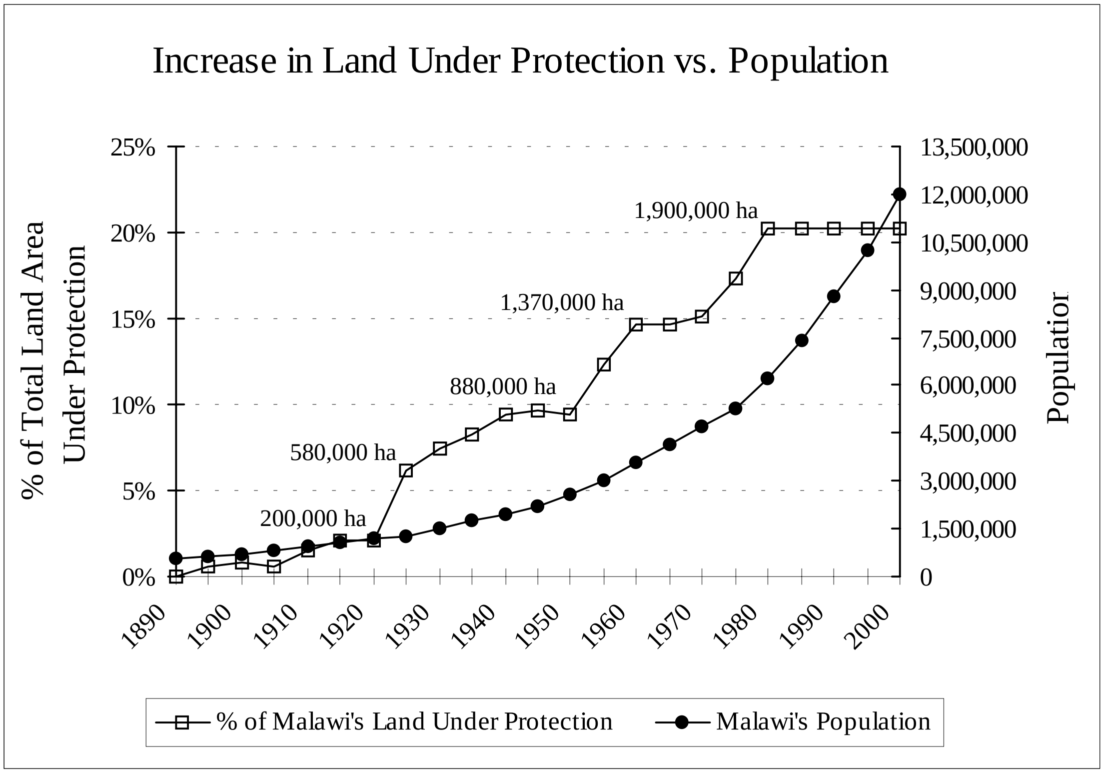

Figure 5. Increase in land under protection relative to growth in population.

Malawi currently has 86 protected areas, the vast majority of which are small forest reserves. The nine wildlife reserves and national parks represent almost 60% of the protected land area (Table 3).

Table 3. Summary of number, type and size of Malawi's protected areas in 1997.

	Number	Area (ha)	% of Total Area	Mean Area (ha)
Forest Reserves	77	769,822	41%	10,843
National Parks	5	710,421	38%	142,084
Wildlife Reserves	4	389,730	21%	97,433
Total	86	1,869,974		21,494

Ten large protected areas make up over 75% of the land area in this sector; the balance is made up of 77 forest reserves, Lake Malawi National Park, and Mwabvi Wildlife Reserve. Four forest reserves exceed 50,000 hectares: South Viphya, Dzalanyama, Mulanje, and Namizima (Figure 6 and Appendix A). There are also 240,000 hectares of ungazetted land, primarily in the customary sector that remain under consideration for protection.

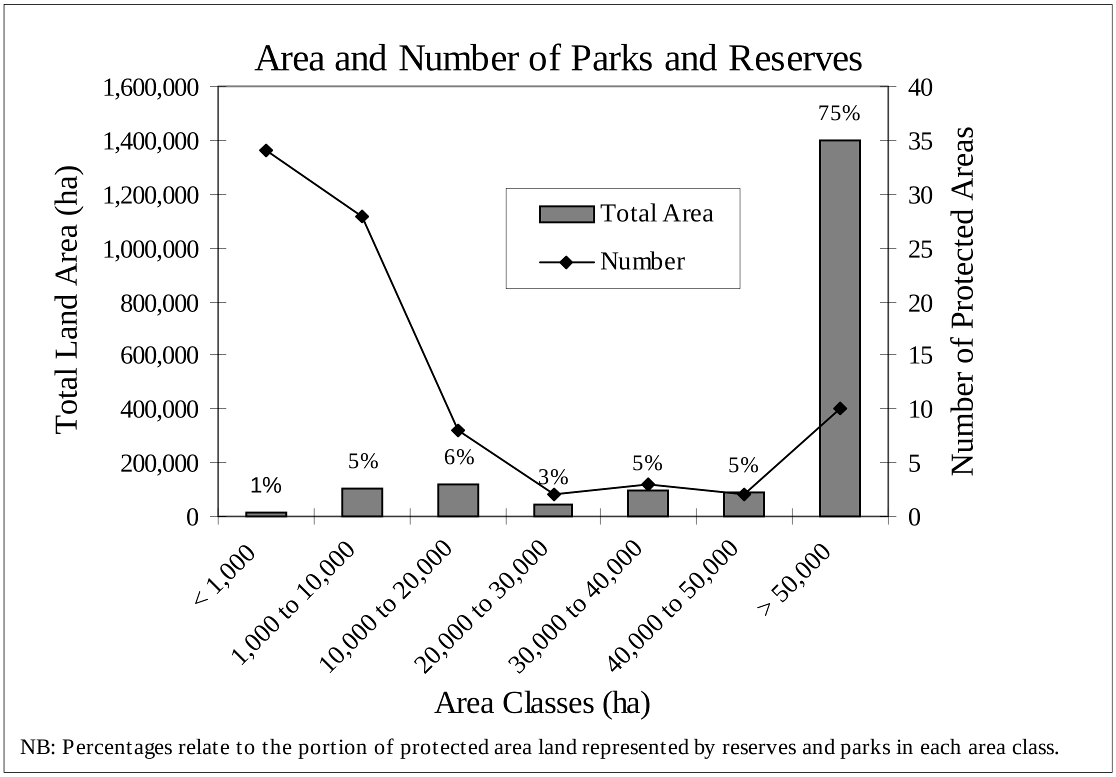

Figure 6. Land area and number of parks and reserves in Malawi.

The primary rationale for forest reserves is catchment protection, although conservation of biological diversity, forest production and protection of urban water supply are also crucial (Figure 7). Most forest reserves were created to prevent steep slopes from serious erosion, with particular concern for the protection of watersheds for rivers and streams. Many of these reserves are situated along rift escarpments or in mountainous areas.

Though only three forest reserves were originally created for conservation of biological diversity, today fourteen are valued for that diversity and the presence of rare or even unique evergreen species such as Mulanje Cedar. Twenty-five reserves have areas dedicated to hardwood and/or softwood production; 65%, or 73,500 ha of the land dedicated to these exotic species are full scale industrial plantations that are profoundly underutilized despite enormous potential. They are capable of 1.1 million m^3 of sustainable annual roundwood production. This would supply 14% of Malawi's annual wood production requirements on only 3% of the country's forested land.[21]
Virtually every forest reserve in Malawi serves as a source of fuelwood and construction materials for local communities, and among those a dozen have formal forestry programs dedicated to augment the supply.

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[21] Davis, C. and R. Gjessing, 1995. Industrial Plantations: Ownership and Management Options. ODA, Lilongwe. The authors report that less than 25% of the logs are currently utilized, and the revenues offset only 19% of current costs, a considerable operating deficit shouldered by the Department of Forestry without adequate resources to manage or develop the plantations. The authors propose several privatization options that could expand employment and generate profits.

Wildlife reserves and national parks come under the domain of the Department of National Parks and Wildlife (DNPW), now within the Ministry of Tourism. As such, one of their growing official uses is tourism focused on large wildlife. In the early days, these protected areas were often called Controlled Shooting Areas, or Game Reserves, established primarily to preserve concentrations of game animals. Generally areas were selected that did not impinge upon economic development or agriculture. These areas often had low population or poor soils, or had special problems such as tsetse fly infestation. Protection was often revoked when areas became required for settlement or if economic objectives behind the protection were not achieved. During much of this earlier period there was debate over preservation for hunting versus the need to protect livestock and cultivated areas from wildlife.[22]

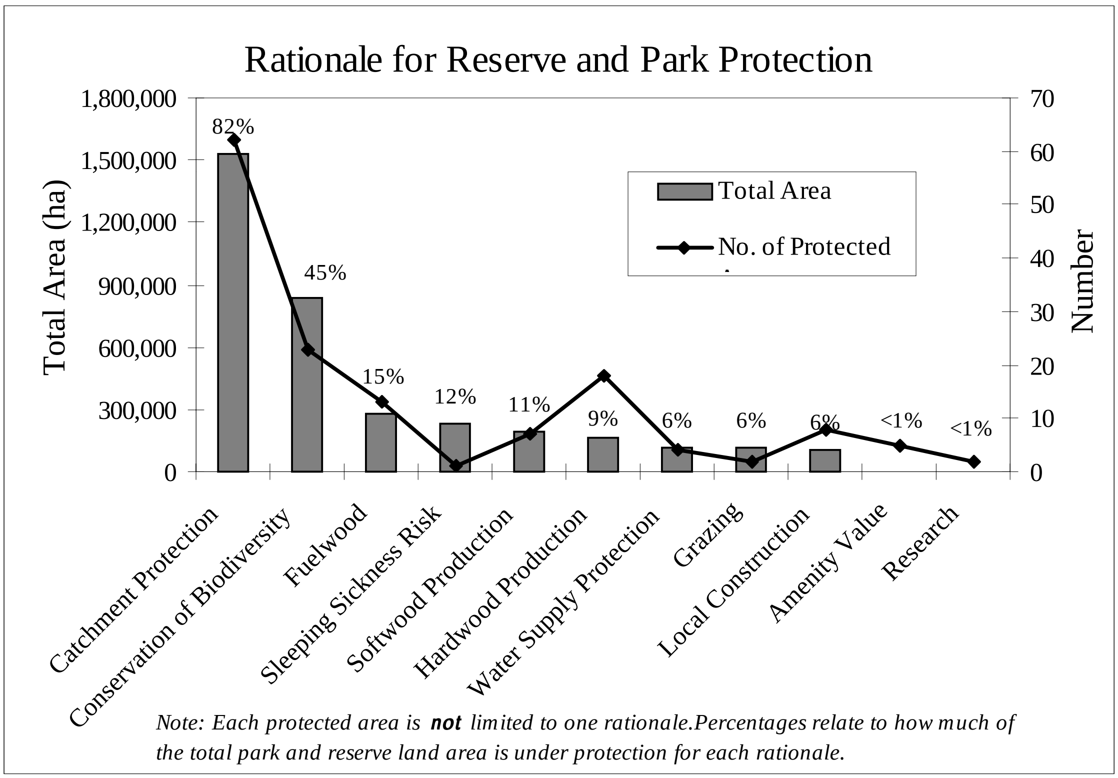

Figure 7. Rationale for protecting Malawi's reserves and parks.

Towards the end of the colonial era the emphasis shifted from preservation to conservation, with a focus on wildlife protection. Over the years since independence, the decline in large wildlife species has brought the rationale of species protection and biodiversity conservation to the forefront.[23] Nonetheless, the great size of the parks and

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[22] The debate over the 1926 Game Ordinance which preserved specific game species pitted hunters against missionaries due to the link between wildlife and the tsetse fly, and the barring of most traditional hunting methods. See Morris, B. 1991. Conservation mania in colonial Malawi: another view. Chancellor College History Seminar Paper No. 9, CSR, Zomba. CC/H/558/91.

[23] A number of references provide species lists of animals found in Malawi's wildlife reserves and national parks: a) GOM, 1983. Protected Areas Master Plan, vol. I-III (one for each region), DNPW, Lilongwe. b) Hough, J. 1989. Malawi's National Parks and Game Reserves. Wildlife Society of Malawi, Blantyre.

wildlife reserves results in a landscape mosaic that includes entire stream basins and often hilly or even mountainous areas. Thus, catchment protection is another key function served by these areas.

The Inter-Agency Working Group on Protected Areas summarized the current rationale for Malawi's protected areas as follows:

- catchment and steep slope protection;
- conservation of wildlife and forest resources through managed utilization, including both consumptive utilization (the harvesting of fuelwood, timber and non-wood forest products; the hunting of game animals) and non-consumptive utilization (primarily tourism);
- conservation of biological diversity, and the preservation of examples of wildland types as a scientific and educational asset; and,
- preservation of wildlands for their aesthetic and amenity values.

3.6 The Quandary: Demand for Land and Demand for Resources

3.6.1 Malawi's Resource Base and the Decline in Forested Area

In 1946, over half the land in Malawi (5.0 million hectares) was forested. By 1991, analysis of satellite images revealed that the forested area had decreased by 50%, down to 2.5 million hectares, or only 27% of the country's total land area. Of this forested area, 1.3 million hectares are found within protected area boundaries. In other words, 53% of Malawi's current natural woodland lies within reserves and parks (Table 4).

Table 4. Ecological resource distribution in Malawi as of 1991.[24]

Resource Class	All Malawi		Protected Areas[25]		*Portion*[*]
	(ha)	(%)	(ha)	(%)	*(%)*
Natural Woodland	2,500,463	27%	1,322,235	71%	*53%*
Tree Plantations	148,016	2%	112,891	6%	*76%*
Natural Grassland	765,541	8%	281,552	15%	*37%*
Partially Agriculture	5,767,488	61%	138,636	7%	*2%*
Other	217,213	2%	14,660	1%	*7%*
Total	9,398,721	100%	1,869,974	100%	*20%*

**Portion* of Malawi's land area for each resource class stocked in protected areas.

The decline associated exclusively with agricultural clearing over the past fifty years has come at a rate of 1.5% per annum. Deforestation is also caused by excessive resource use, although the impact may be a reduction of canopy rather than clear-cut plots. In these cases, the reduction in canopy and overall biomass may be quite significant, but not enough to be considered a change in land cover class. Recent estimates suggest that the

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c) Carter, J. 1987. Malawi Wildlife, Parks and Reserves. Macmillan, London.

[24] PLUS conducted an analysis of Forestry/Satellitbild digital land cover developed through interpretation of 1991 Thematic Mapper images (30 m resolution). For details on that study, see Satellitbild, 1993. Forest Resources Mapping and Biomass Assessment for Malawi. Satellitbild, Lilongwe.

[25] "Protected Areas" refers only to those that are considered government land, representing 20% of Malawi's land area. An additional 2.5% (238,907 ha) is under "proposed" status and is not analyzed under public land.

decline in forest biomass related to selective deforestation combined with the clearing of whole areas for agriculture amounts to a 3.5% decline in total forest resources each year.

3.6.2 Consumption of Woody Resources: Sustainable Supply vs. Demand

The Forestry Research Institute of Malawi (FRIM) has made estimates of the growing stock and yields of Malawi's trees within all of the country's land cover classes.[26] The results of that analysis can be applied to the 1991 land cover mapping conducted by Forestry/Satellitbild[27] to compute Mean Annual Increment (MAI) volumes for all of Malawi (Table 5). These figures permit an assessment of the annual sustainable supply of woody resources.

Table 5. Mean annual increment analyses of land cover types.

Land Cover Sub-Class[27]	Area --(ha)--		MAI rate[26] (m^3/ha/yr)	MAI Volume --(m^3)--	
Evergreen forest	82,595		3.4	280,823	
Miombo in flat area	731,523		4.4	3,218,702	
Miombo in hilly area	1,686,345		3.7	6,239,477	
Natural Woodland Subtotal:		*2,500,463*			*9,739,002*
Eucalyptus	24,043		20	480,854	
Gmelina	722		10	7,219	
Leucaena	6,615		10	66,147	
Logged area	4,979		10	49,790	
Pine	107,282		17	1,823,798	
Rubber	2,665		0	0	
Tung	1,710		10	17,101	
Plantation Subtotal:		*148,016*			*2,444,909*
Grass	312,471		0.5	156,236	
Dambo, often cultivated	413,911		0.5	206,956	
Savanna	39,158		1	39,158	
Predominantly Grass Subtotal:		*765,541*			*402,350*
Agriculture in forest area	2,431,192		4.7	11,426,602	
Agriculture in mainly grass area	233,649		0.5	116,825	
Arable land	2,785,972		0.5	1,392,986	
Coffee/Tea/Macadamia	44,332		1	44,332	
Rice scheme	7,350		0.5	3,675	
Sugar	20,623		0.5	10,311	
Tobacco & Maize	244,370		1	244,370	
Predominantly Agriculture Subtotal:		*5,767,488*			*13,239,101*
Built-up area	22,443		0	0	
not classified	2,182		0	0	
Bare rock	15,620		0	0	
Marshy area, often partly cultivated	176,504		0	0	
River bed or beach	464		0	0	
Other Subtotal:		*217,213*			*0*
Grand Totals:		*9,398,721*			*25,825,362*

NB: the MAI rates vary by region. For this analysis an aggregate national figure is used.

[26] Masamba, C. and J. Ngalande. 1997. Inventory Data of Biomass Growing Stock and Supply. FRIM, Zomba.

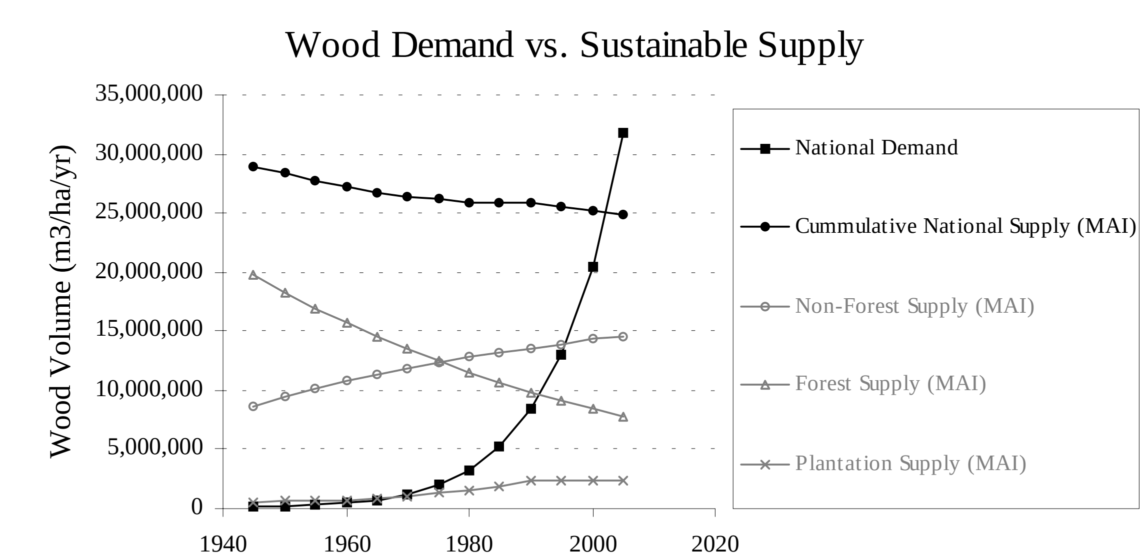
[27] Satellitbild, 1993. Forest Resources Mapping and Biomass Assessment for Malawi. Satellitbild, Lilongwe.

The demand side of the equation can be assessed through official estimates of wood consumption from the Forestry Department (Table 6). These figures show that demand is increasing at 9.25% per year.

Table 6. Forestry department wood consumption figures.[28]

General Consumption		1989	1995	% increase
		(m^3)		
	Rural households	5,000,000	8,500,000	70%
	Urban households	800,000	1,300,000	63%
	Tobacco & tea estates	400,000	700,000	75%
	Modern Industries	400,000	600,000	50%
	Rural industries	200,000	600,000	200%
Formal Industry				
	Industrial poles	800,000	1,200,000	50%
	Industrial wood processing	100,000	200,000	100%
Grand Totals:		*7,700,000*	*13,100,000*	*70%*

The combination of sustainable supply and demand figures can be evaluated over time, with the assumption that the changes year to year correspond to the rates available. Spatial analysis permits application of the volumes reported in Table 5 to geographic land areas by class. Figure 8 depicts the results of the analysis over time.



NB: "Sustainable supply" refers to the Mean Annual Increment (MAI)--each year's new growth measured in m3 per hectare per year. "Cummulative National Supply" is drawn from forests and plantations as well as wood from non-forested areas in the agricultural sector. "National Demand" is based on all wood consumption.

Figure 8. Wood demand versus sustainable supply in Malawi.

[28] The estimates for 1995 from the Forestry Department are higher than those reported by the Ministry of Energy and Mines (11,360,000 m3) – it is assumed the difference relates primarily to industrial consumption. If the Ministry of Energy and Mines figures were used, demand would increase at just over 7% per year, intersecting sustainable supply a few years later than shown in Figure 8.

Note that this figure shows that sustainable supply will be exceeded demand within the next three years, giving some urgency to reaching land use and land tenure policy decisions.

The pace of decline in sustainable wood supply from forests exceeds that of national supply due in part to clearing for cultivation (1.5%/yr in this analysis). The national supply is also supplemented by the effect of fast-growing exotic trees on agricultural land and on government plantations. It is generally assumed that forest decline could soon reach a point in the future which would dramatically impact the annual yields of trees on agricultural land as alternative wood sources become more difficult to obtain. In such a scenario, the rate of decline in sustainable supply would accelerate rapidly. As it stands, the analysis shows that sustainable supply will be outstripped by wood demand by 2003.

The bulk of the demand is related to fuelwood, demonstrating the very difficult choice faced by smallholders seeking land. Wood represents the source of fuel for cooking and heating water for 98% of rural households. Virtually all other activities that require energy in rural households rely on fuelwood as well.[29] Though the form of wood-based fuel can vary, the story is quite similar in urban areas. Combined, charcoal and firewood represent 94% of the total energy consumed in urban households.[30] Measured in terms of the incidence of supply, protected areas are the source of 25% of the fuelwood and 12% of the charcoal needs of Malawi's four major cities.[31]

Protected areas represent over half the remaining stocks of forest resources in Malawi. At the same time these areas make up almost 20% of the country's land area—land area which, regardless of suitability, has not been converted to agriculture. It is clear that protected land in Malawi faces pressure from competing interests, often by the same people. The dilemma involves the demand for land, and the continuing demand for resources from that same land.

Protected areas provide much more than wood resources to local communities and even to Malawi's regional and national markets. A host of food, thatch, and medicinal products are obtained from over 680 species of plants and animals were identified by villagers living adjacent to the five Level 2 protected areas studied intensively (see Chapter 7 for details and Appendix E for a species list). A number of references provide excellent detail the great variety of traditional uses for wild animal and plant species throughout Malawi.[32]

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[29] Energy Unit, 1981. Malawi Rural Energy Survey. Ministry of Agriculture, Lilongwe, p. 4)

[30] Arpaillange, J. 1996. Urban Household Energy: Demand Side Strategy, Main Report. SEED/Ministry of Energy and Mining, Lilongwe, section 2.15.

[31] Openshaw, K. 1996. Urban Biomass Fuels: Production, Transportation, & Trading Study. Alternative Energy Development/Ministry of Energy and Mines, Lilongwe, p. 15-16.

[32] At the national level, the major sources are: a) Williamson, J. 1975. Useful Plants of Malawi, rev. ed. University of Malawi, Zomba

b) Seyani, J. 1990. The Potential Value of the Malawi Flora in Development , National Herbarium, Zomba.

c) Maghembe, J. and Seyani, J. 1991. Multipurpose Trees Used by Smallholder Farmers in Malawi: Results of an Ethnobotanical Survey. Agroforestry Research Network for Africa, Report No. 42.

d) See Eschweiler, J. 1993. Malawi Land Use Issues. World Bank, Lilongwe/Kortenhoef.

Eschweiler used these to provide an analysis by ADD, and in Appendix IV, lists other sources.

3.6.3 Potential Revenue from Official Income Generating Use of Protected Areas

There are very few figures available on actual or potential revenues generated from the use of protected areas in strictly economic terms. Those that are available are focused on official use of the land and do not attempt to quantify intangibles such as biological diversity, or downstream effects such as the impact of changes in protection on the supply of critical resources. One of the recommendations of this study is to include such an analysis as a step in the decision making process for specific tracts of land under pressure for change in tenure (see Chapter 8 for details). Unofficial use is also difficult to quantify; Chapter 7 provides information on the community-level resource utilization by providing an analysis on the importance of protected land and resources to the livelihoods of those living adjacent to parks and reserves.

3.6.3.1 Tourism

Despite the lack of overall data, a rudimentary analysis on major income generators such as tourism can be done through the use of detailed studies conducted on specific parks or reserves. In particular, the Kasungu National Park Management and Land Use Plan projected tourism revenues.[33] The Kasungu results can be converted to a per hectare basis and then applied to wildlife tourism in all nine national parks, wildlife reserves, and at least three forest reserves (Mulanje, Tuma, and Zomba-Malosa are considered to have high tourist potential). This assumes that all the areas have similar potential in attracting tourists, which today is not the case. Unfortunately, statistics on their potential in the future were not available and therefore the model for Kasungu was applied throughout.

The result is an estimate of potential tourist revenue (i.e. entry, activity and lodging fees) directly linked to the protected areas (Table 7). To assess the impact on tourism receipts as a whole for Malawi, a multiplier for rate of receipts per tourist (USD 60 per tourist) was derived from 1989 World Tourism Organization figures reported for Southern African Development Co-ordination Conference (SADCC) countries. Apparently, Malawi's rate of receipts per tourist is significantly lower than that of Africa as a whole (USD 329 per tourist); this much higher multiplier is used in the final column.[34 and 29]

Table 7. Estimated potential revenue from tourism in parks and reserves.

	Qty	Area (ha)	Potential Tourists (per year)	Potential Fee Revenue (USD)	Potential Tourist Receipts[29] (USD) (Malawi Multiplier)	(Africa Multiplier)
National Parks	5	710,421	21,003	$289,354	$1,256,595	$6,891,204
Wildlife Reserves	4	389,730	11,522	$158,737	$689,356	$3,780,448
Forest Reserves	3	82,335	2,434	$33,535	$145,635	$798,667
Total Potential:		1,182,487	34,959	$481,627	$2,091,586	$11,470,320

NB: all tourist and fee revenue projections are based on estimates for Kasungu National Park and thus do not account for variation in potential among these protected areas.

This analysis suggests that if tourism development like that proposed for Kasungu National Park were to be replicated in the other reserves and parks noted above, it could

[33] Bell, R., Banda, H., Mkwinda, and S., Nothale, S. 1993. Kasungu National Park Management and Land Use Plan. DNPW, Lilongwe. Table 5.1: Projections, Tourism Statistics.

[34] Attwell, C. 1992. Regional Survey of Wildlife Utilization in SADCC Countries, Vol. I: Main Report. FAO, Rome, p. 4.

generate almost USD 500,000 in fees each year. It would also contribute to over USD 2,000,000 in foreign exchange receipts to the economy, based on Malawian tourism figures of 1989, and potentially over USD 11,000,000 if Malawian receipts per tourist were to reach the mean level for all of Africa in the long term.[35]

3.6.3.2 Industrial Plantations

In the forestry sector, developments on government plantations could also have a major impact on economic revenue. The privatization options proposed by consultants to the government in 1995 could quadruple current revenues to USD 5,000,000. The proposed changes could result in the plantations generating not only profits, but also five times the currently associated employment (12,000 jobs in management, harvesting and basic saw milling, and 10,000 in the development of value added products).[36]

3.7 Agricultural Schemes

PLUS focused primarily on protected areas. However, in response to a request from the Ministry of Agriculture and Irrigation, an attempt was made to assemble a list of all government owned agricultural schemes in Malawi. This task proved to be much more difficult than originally anticipated as there are many different Malawian agencies responsible for these schemes and rarely did two agencies submit identical lists. However, PLUS did identify 82 schemes responsible for research, training, irrigation, specific crop production, grazing, veterinary services, and settlement. In a number of cases, the current ownership status of a scheme was not clear (see Appendix B for details). In other cases the scheme had been defunct for years, occasionally not even showing up on government accounting books, but was still considered to be government owned by at least one agency. PLUS digitized all those schemes to which it could obtain even sketch maps with adequate geographic registration (often higher quality maps were unavailable) in the hopes that the Ministry will improve this spatial representation once the official list is verified by all parties.[37]

The total area for agricultural schemes comes to 217,651 hectares. However, they are not evenly distributed by type or geographic location in Malawi (Table 8). [38] Tobacco and Livestock schemes make up over 80% of the total agricultural scheme area (though almost 75% of the latter is due to Dzalanyama Ranch). By ADD, Lilongwe, Kasungu and Mzuzu represent 80% of the total land area and most of this is within three districts (Kasungu, Lilongwe, and Mzimba).

[35] These figures should be used with caution as it is not clear why there is such a difference tourist receipts per tourist arrival between the Malawi versus Africa as a whole (see footnote 28 for reference).
[36] Davis, C. and R. Gjessing, 1995. Industrial Plantations: Ownership and Management Options. ODA, Lilongwe, p. 23.
[37] As of publication, PLUS was unable to digitize 23 of the 82 identified schemes, half due to lack of mapping information, half due to missing geographic coordinates for registration.
[38] Of this area, 66,574 belongs to Dzalanyama ranch—this amount is subtracted from the Agricultural Scheme land area total to reach the rounded off figure of 150,000 ha reported in the land balance analysis in Chapter 2. This was done because Dzalanyama Ranch is part of a co-management arrangement with Dzalanyama Forest Reserve; the boundaries of the latter take up all of the Ranch and beyond. By subtracting, we avoided double counting this land area in that analysis.

Table 8. Distribution of agricultural scheme land by type, ADD and district.

Type	Area (ha)	District	Area (ha)
Irrigation	18,036	Blantyre	683
Livestock	89,387	Chikwawa	7,839
MYP Training	1,609	Chiradzulu	4,115
Research	3,190	Chitipa	1,203
Settlement	15,874	Dedza	232
Water	5	Dowa	252
Training	494	Karonga	10,682
Tea	65	Kasungu	59,785
Tobacco	88,992	Lilongwe	67,739
		Machinga	2,083
Total Area	*217,651*	Mchinji	2,022
		Mulanje	600
ADD	Area	Mzimba	38,297
	(ha)	Mzuzu	648
Blantyre	5,876	Nkhata Bay	2,541
Karonga	11,885	Nkhotakota	2,323
Kasungu	63,631	Nsanje	1,089
Lilongwe	67,971	Ntcheu	66
Machinga	3,105	Ntchisi	1,572
Mzuzu	41,486	Salima	12,381
Salima	14,769	Thyolo	478
Shire Valley	8,928	Zomba	1,022
Total Area	*217,651*	*Total Area*	*217,651*

There are a number of schemes often assumed to be on public land that are actually on customary or estate land, or have been privatized in the recent past. These include Kawalazi Smallholder Tea Authority; Luweya, Mpamantha, and Bua Irrigation Schemes; and, Mbwabwa, Nkhamanga-Thulwe, Nkozo, and Nyaza Settlement Schemes. A number of these were purchased by Spearhead, Ltd., a company formed by the Malawian Young Pioneers (MYP) that later went into receivership. Some have been repurchased and are being farmed under assignment.

Privatization efforts of farms and ranches maintained by the Ministry of Agriculture and Irrigation have focused on Kaombe, Chipazi, Bwemba, Tuchila, Kuti, Kabumbu, Choma, Meru, Dzalanyama, Mikolongwe, Mpemba, Kasikidzi, and Lifidzi. Analysis has also been conducted on all smallholder authorities, including those occupying public land. These include the Kasungu Flue-Cured Tobacco Authority (KFTCA) and both the

Mulanje and Thyolo Tea Authorities.[39] Rehabilitation of the irrigation schemes has been studied intensively on at least four occasions in the past 25 years. A recent government study provides excellent detail on each scheme and outlines options for transfer of management and/or ownership functions to the private and customary sectors.[40]

Most agricultural schemes (aside from livestock ranches and holding grounds) are on lands suitable for, and often already engaged in, agriculture. Thus, any change in land tenure on these lands will not risk the major environmental impacts faced by protected areas. As can noted from the list in Appendix B, a number of the schemes are defunct (in some cases, for many years) and others have limited operations or have been heavily encroached. The current government efforts towards the general liberalization through reorganization and at times divestiture of public entities includes those within the agricultural sector. The Department of Irrigation has taken the lead in evaluating the pros and cons of handing these areas over to local inhabitants.

PLUS recommends the self-evaluation precedent begun by the Department of Irrigation be followed for all agricultural schemes to ensure that only those that are fully functioning and meeting current policy objectives remain under government ownership and/or management. Those that have the economic potential to function profitably as going business concerns should be reviewed by the privatization commission. Those that show promise for management and/or ownership by local inhabitants, either through cooperative arrangements or within the customary structure, should be transferred. These steps require careful study and the involvement of local stakeholders, as recommended in the second phase of the framework for decision making in Chapter 10.

[39] Bailey, L. 1995. Overview and Assessment of State Owned Enterprises in the Agricultural Sector. Economic Policy Support Unit and the Ministry of Statutory Corporations, Lilongwe.
[40] Department of Irrigation, 1994. Handover of Government Irrigation Schemes to Farmers, Main Report and Annexes (two volumes). Ministry of Agriculture, Lilongwe.

4. STUDY OVERVIEW

4.1 Study Approach and Report Organization

The PLUS methodology was developed and conducted at two levels of analysis. Level 1 involved the use of available maps and aggregate data to physically characterize public lands across all of Malawi. Level 2 concentrated on the physical and socio-economic dynamics associated with five selected protected areas. The next six chapters are organized in the same manner as the analysis. See Figure 9 for a schematic view of the major stages of analysis.

The next five chapters are organized in a similar manner to the actual analysis, beginning with the intensive study of the Level 2 sites. These assessments are followed by a national assessment of the protected areas at a much coarser resolution. The final chapter provides a decision making framework for those potential land tenure change requests that are focused on a specific tract of land. The *Nature of the Resource* for the five Level 2 sites is described in Chapter 5, including the models used to assess agricultural suitability, erosion hazard, and environmental suitability for agriculture.

The models of the potential influences of population density and ease of access that were developed and used to ascertain the pressure on the resource follow in Chapter 6, *Pressure on the Resource*. The importance of protected area land and resources to the livelihoods of communities adjacent to protected areas is detailed in a socio-economic analysis of the *Community-Level Resource Utilization* in Chapter 7. The *Impact on the Resource*, due to pressure for land and resources is analyzed in Chapter 8. *National-level Model Results* are discussed in Chapter 9, and a framework for *Incorporating Results into Policy* is presented in the final chapter.

Field research for PLUS began in April 1996 with a pilot study in the Zomba-Malosa Forest Reserve and finished with final ground verification efforts a year later. Analysis, modeling and interpretations of the results culminated in a two-day presentation presented at the PLUS Closing Seminar in November 1997. There, 85 participants representing stakeholders in land issues from over 60 interest groups in Malawi responded to the information and debated the key policy issues. The results of the PLUS analysis as well as the feedback received at the Closing Seminar have been incorporated into this Final Report. All spatial and tabular data have been written to CD with associated data manuals and will be stored in the repositories noted in section 4.4

Figure 9. General framework for PLUS analysis.

4.2 Selection of Protected Areas for Intensive Study

During the conception of the land utilization studies, the Lands Steering Committee recognized that available, national-level, digital data were inadequate for the kinds of analysis requested of PLUS. It also recognized that each protected area was unique in its resources, pressures, and potential. For these reasons the Committee proposed a purposive sampling strategy for intensive study of five protected areas. The Committee developed selection criteria and then had the associated line agencies (Lands, Forestry, Parks & Wildlife, Environmental Affairs, and Agriculture) debated site selection options for more than four months until the sites listed in Table 9 were selected. Those criteria were:

1. *Pressure:* actual and potential human impact on public land and resources;
2. *Risk:* threat to watershed protection, biodiversity, habitat, etc.;
3. *Opportunities:* potential for the protected area to provide "lessons learned" (i.e. strong case study potential) which could be applied to other areas, and;
4. *Alternatives:* protected areas with management strategies already in place that integrate community use with official resource use.

Table 9. Level 2 sites selected for PLUS.

Protected Area	Type	Region
Mulanje	Forest Reserve	South
Zomba-Malosa	Forest Reserve	South
Liwonde	National Park	South
Dzalanyama	Agricultural Scheme (Ranch) & Forest Reserve	Central
Vwaza	Wildlife Reserve	North

4.3 Summary of Methods

The intensive Level 2 analysis exploited all of the methods summarized in Table 10 while the national Level 1 analysis was limited to the techniques noted with an asterix. The methodology used for each component of PLUS is detailed at the beginning of the chapter where the associated analysis and results are presented.

Table 10. Data collection and analysis techniques used in PLUS.

Method	*Chapter*	*Method*	*Chapter*
*Spatial Data Capture	4	Secondary Data Collection	1-10
*Base Mapping	4	Rapid Appraisal	7
*Agricultural Suitability, Erosion Hazard,	5	Formal Household Survey	7
*Access, Population Pressure, and Impact Models	6,8	Participatory Mapping	7
Land Cover Classification & Change Detection	8	Key Respondent Interviews	7
*Protected Area Creation Rationale	2	Resource Assessment	7

*techniques used in the Level 1 (national) analysis

The spatial analysis required the collection of existing digital data and the capture of data through digitizing of analog or hard copy maps from a variety of sources and stored at several different scales (Table 11). The data were checked for accuracy and "cleaned" where necessary or re-digitized to provide better accuracy than that originally available. Remotely sensed Landsat Thematic Mapper (TM) data were processed, classified, used in models, and merged with other spatial data. These data were used to derive analytical data which could be spatially mapped or modeled to better portray and understand the nature and distribution of the public land resources, and pressures and impacts on these protected areas. The improved spatial resolution of data for these Level 2 sites provides a much better understanding of physical factors and risks associated with any tenure change in the future. For Level 2 models, a data cell size of 30 meters was used whereas for

Level 1, a data cell size of one kilometer was used in the modeling. The primary input layers for Level 2 modeling detailed in Chapters 5,6,8 and 10 are depicted in Figures 10-14. ESRI ArcInfo™ and ArcView™ were used for geographic information system analysis (GIS) and PCI™ as well as Erdas Imagine™ were used for image processing.

Table 11. Data scales spatial data captured.

1:50,000 Survey Sheets
Reserve and Park boundaries for Level 2
Topography (every 200 or 250 ft contour lines)
Hydrology (streams)
Roads and tracks
Villages involved in PLUS socio-economic analyses
1:250,000 Map Sheets
Soils/ Physiography Maps digitally joined with extensive relational database (LREP Map Series)
Agro-climate Maps with relational database (LREP Map Series)
National Reserve and Park boundaries
Smaller Scale Maps or Data
National-Level FAO Soils (1:5,000,000)
National-Level Digital Elevation Models (DEM, 1km)
National-Level Hydrology (Streams, water bodies)
National-Level Transportation (Roads, Railroads)
Major Cities
Administrative boundaries (Region, District, EPA, ADD)
Landsat (Thematic Mapper) Satellite Image Data (30 meter resolution)
Enhanced False Color Composites (FCC), TM bands 4,3,2
Georeferenced 1984 Land Cover Map for Level 2 sites
Georeferenced 1994 Land Cover Map for Level 2 sites
National 1990/1991 TM derived Land Cover Map
National 1972/1973 MSS derived Land Cover Map (80 meter resolution)
Derived Digital Layers
Digital Elevation Models (DEM)
Slope and Aspect Images
Shaded Relief Images simulating TM acquisition date conditions
Land Cover Change Maps (1984-1994) at Level 2, and 1972/73 - 1990/91 for national level
Agricultural Suitability Model Results (generalized LREP models)
Erosion Hazard Model Results (modified SLEMSA)
Environmental Suitability Model Results (Erosion Hazard + Agricultural Suitability)
Access Model Results
Potential and Direct Population Pressure Model Results
Pressure on the Resource Model Results (Merging of Potential population + Access)
Impact and Population Comparison Maps
Impact and Access Comparison Maps

Figure 10. Primary reference data for Mulanje Forest Reserve.

Figure 11. Primary reference data for Zomba-Malosa Forest Reserves.

Figure 12. Primary reference data for Liwonde National Park.

Figure 13. Primary reference data for Dzalanyama Forest Reserve.

Figure 14. Primary reference data for Vwaza Wildlife Reserve.

4.4 Repositories of PLUS Products

A set of spatially referenced digital and hard copy maps and associated descriptive data have been developed for PLUS describing the general nature of land and land use of Malawi's public lands. The analog maps are available in this report while the digital information is contained on a set of seven CDs. Repositories for the spatial information include Lands, Parks & Wildlife, Forestry, Land Resources Conservation, and Surveys. The socio-economic and ecological data are housed at FRIM, Chancellor College Sociology Department, Centre for Social Research (CSR), and the Agriculture Policy Research Unit (APRU) at Bunda College.

This final report was issued to all members and visitors to the Lands Steering Committee, the members of the Land Policy Reform Commission, other stakeholders local and national participating in the study, and to all chiefs directly involved in the Level 2 data collection. In all, some 300 copies of this report have been prepared and distributed.

PLUS methods and digital data have been structured for future use as part of a prototype Environmental Information System (EIS). This new effort is being coordinated by the Environmental Affairs Department and involves a number of the agencies participating in the Lands Steering Committee.

4.5 Level II Protected Area Descriptions

The following general descriptions of the five Level II sites with emphasis on land pressure were developed through reports from the Forestry Department, Department of National Parks and Wildlife (DNPW), the Inter-Agency Working Group on Protected Areas and a variety of site specific articles and documents.[41]

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[41] a) Inter-Agency Working Group on Protected Areas. 1997. Protected Areas: Their Role and Future in Malawi's Land Budget. A Memorandum Submitted to the Presidential Commission of Inquiry on Land Policy Reform. Lilongwe.
b) Department of Forestry, 1993. A Register for Forest Reserves for Malawi. GOM, Lilongwe.
c) DNPW, 1983. Principle Master Plan for National Parks and Wildlife Management. Lilongwe, Commonwealth Fund for Technical Cooperation. These data were updated by members of each department.
d) Mwikhoma, J. Zomba Mountain Forest. (Summary Paper), Zomba District Forestry Office, Zomba.
e) Dudley, C. and D. Stead. 1976. Liwonde National Park: part I – an introduction. Nyala. 2 (1) 17-28.
f) Powell, J. 1996. Public Attitudes and Resource Needs Assessment of Villages Surrounding Liwonde National Park. DNPW; U.S. Peace Corps, Liwonde.
g) Gibbons, T. 1996. An Assessment of Public Attitudes and Resource Needs of Smallholder Families, Liwonde. Malawi Wildlife Society.
h) Ngalande, J. 1995. An Integrated Management Plan for Dzalanyama Forest Reserve: Malawi. Masters Thesis, University of Aberdeen.
i) McShane, T. 1985. Vwaza Marsh Game Reserve: A Baseline Ecological Survey. DNPW; U.S. Peace Corps, Rumphi.
j) Jayne, S., K. Hess, D. Koehler, 1996. Community Resource Utilization Report: Vwaza Marsh Wildlife Reserve, Malawi. DNPW; U.S. Peace Corps; Volunteers in Overseas Cooperative Assistance.

4.5.1 Mulanje Forest Reserve

Mulanje Mountain was first gazetted as a forest reserve in 1927, with the nearby Michesi Mountain added in 1929. Today the reserve covers 56,314 ha of mostly mountainous terrain, and serves to protect a number of catchment sources from erosion while also conserving considerable biological diversity that includes wildlife and some unique tree species such as Mulanje Cedar (*Widdrington nodiflora*). The reserve also serves as a tourist attraction and a source of high quality timber. A large *Eucalyptus* plantation in the southeastern portion of Mulanje was designed to supply fuelwood and charcoal locally and to urban centers, though problems of accessible, inexpensive transport have limited progress towards these objectives.

During the first 20 years of Mulanje's protection, a number of estates in the Fort Lister gap between Mulanje and Michesi were surrendered, and the reserve boundaries were adjusted in 1935, 1948, and 1958. The first encroachments were reported near the southern boundary in 1962, and over the next two years several excisions were made. From this time onwards encroachment became increasingly evident as land pressure in the customary sector increased. A Boundary Commission, established in 1978 to help resolve the growing conflict, did not report until 1982, when there was a sudden escalation in encroachment along the southern and eastern slopes and again in the Fort Lister area, with violent clashes between smallholders and the Forestry Department staff. The Commission recommended eleven excisions totaling 812 ha; these were approved and implemented by 1987. In the meantime, as much as possible of the encroached land was planted with *Eucalyptus* in order to minimize erosion risks. The boundary of reserve has in effect been pushed progressively higher up Mulanje, exposing fragile mountain slopes to erosion and flash floods. Nonetheless, PLUS rapid appraisal information indicates that despite the marginal quality of most land in the reserve, if given a choice, local inhabitants would be more inclined to request access for cultivation inside the reserve on those steep slopes, rather than on the large estates in the valleys below. Such a choice apparently would be driven by concern of potential displacement of landholders that would not occur on public land.

The Mulanje Conservation Trust has recently completed a difficult series of financial and organizational steps and is now fully active. One of its objectives is to integrate local stakeholders into the decision making process on issues affecting the reserve. The trust includes representation of the local Traditional Authorities (TA), Chiefs Mabuka, Jema, Mkumba, Nkande, and Nazombe.

4.5.2 Zomba-Malosa Forest Reserves

Zomba Mountain Forest Reserve was constituted in 1913, making it the oldest in Malawi. Malosa Mountain was gazetted in 1924 and is generally considered a separate reserve. PLUS combined the two (for a total area of 19,018 ha) because national survey maps do not provide a boundary line between the two. As early as 1902, some planting of Mulanje *Cedar (Widdrington nodiflora*) and Mexican Cypress (*Cupressus lusitanica*) was conducted on Zomba Mountain. Today, one of the major functions of the Zomba plateau

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k)AGRAR-GIBB, 1995. Feasibility Study on the Sustainable Management of Nyika National Park and Vwaza Marsh Game Reserve, Vol 1 Main Report. AGRAR-GIBB, Essen, Germany.

and its outer slopes today is softwood production (2722 ha), with and estimated plantable area of 4,100 ha. The major plantation species is Patula Pine (*Pinus patula*), though some other conifer species and *Eucalyptus* are in evidence. It the estimated maximum potential annual yield of approximately 49,000 m^3 of logs, giving about 17,000 m^3 of sawn timber. Softwood trials in 1958 did not suggest the potential for large-scale plantation forestry in Malosa, primarily due to problems in access. Beyond forestry use, Zomba Mountain in particular shows great potential for tourism.

Both Zomba and Malosa serve to protect vital catchments, particularly the protection of the Domasi River, much of which is surrounded by a peninsula of customary land that splits the two reserves. Zomba Mountain was the original site for most of the villages now located within that pocket of customary land, dating back prior to the now legendary resolution of the "Kalongonda Conflict" between the Yao and the Ngoni. These villages were moved in 1949 as a result of changes made in the reserve boundary. Independence in 1964 sparked an effort by these villagers to return to land on Zomba plateau their families had farmed in the past. Encroachment was also reported across the valley on Malosa Mountain. These conflicts were tried in court and settled in favor of maintaining the gazetted boundaries. Today some encroachment still occurs and there is still pressure for the return of ancestral land. These concerns have been exacerbated by district administration control over Malinda Hill, a portion of customary land that now is planted with *Eucalyptus* lying between the two reserves. PLUS did not learn of any adaptive management programs in place for the Zomba-Malosa Forest Reserves.

4.5.3 Liwonde National Park

Liwonde National Park, originally a Controlled Area for managed game hunting, was constituted as a National Park in 1972. In 1976 a corridor was added in the northeast to facilitate elephant movements to and from Mangochi Forest Reserve In addition, a 1 km wide by 35 km long strip was added to the western bank of the Shire River to act as a buffer for wildlife. Today the Park encompasses 54,633 ha of predominantly flat topography with soils ill suited for agriculture. Liwonde serves to protect wildlife in the Upper Shire and to preserve an example of Mopane Woodland (*Colophospermum mopane*). Several endangered species are of prime concern including what at one time was a large elephant population, sable antelope, and Lilian's lovebird, which is indigenous to Malawi.

Tourism is the official primary use of the park, with a primary objective to attract the high revenue tourists to Malawi. Mvuu Camp, which opened in 1993 as a private tourism operation, is an example of this effort. The Park also serves a critical catchment protection role for the Shire River.

Reports from as early as 1868 indicate that the area occupied by Liwonde National Park was rich in wildlife, but lenient regulations led to a tremendous influx of hunters. By the 1920's, the game populations had been drastically reduced (note that today several species are extinct from the Park, including roan antelope, buffalo, Lichtenstein's hartebeest, and zebra). The dangers of elephants to cropland and hippopotamus to river navigation led to vigorous attempts at their eradication. In 1962 the status of "Controlled Area" was proposed and then approved by Chief Liwonde, however illegal hunting continued. It was prohibited entirely in 1969 and three years later, National Park status was granted.

This decision resulted in the relocation of some human inhabitants and since that time there have been several reported cases of encroachment, particularly in the eastern boundary of the Park. In 1988, an area of 100 km^2 was officially excised in a land settlement. In recent years, friction between communities adjacent to Liwonde and DNPW officials have ranged from controls on access to resources, casualties among the local population and sizeable crop damage due to elephants, vandalism of the fence designed to keep wildlife within the park, and continued illegal hunting. This tension has led to an attempt to integrate stakeholders in the future of the Park. The focus to data has been on intensified extension and education efforts and the creation of the Liwonde National Park Advisory Committee. This organization has inter-linked local communities, DNPW, tour operating groups, and the Wildlife Society of Malawi. The TA's representing the local inhabitants include Chiefs Sitola, Kalembo, Chowe, and Liwonde.

4.5.4 Dzalanyama Ranch and Forest Reserve

The history of protection in Dzalanyama actually began with the creation of a game reserve called Central Angoniland in 1911. The expansion of cultivation into the Dzalanyama ranges and lowlands alarmed government officials as the water supply of local streams and both the Diamphwe and Lilongwe rivers were viewed to be at risk. To ensure their protection, Dzalanyama Forest Reserve was constituted in 1922.

In 1966 Malingunde dam was built, one of two dams that are fed from tributaries within Dzalanyama in order to provide water to Lilongwe. In 1970, Dzalanyama became the largest co-managed protected area in Malawi when most of its lowlands were opened to a government livestock scheme upon the establishment of Dzalanyama Ranch. The forest reserve also provides fuelwood supply (including a large portion of that demanded by Lilongwe), in part derived from Patula Pine (*Pinus patula*) and *Eucalyptus* plantations. Today the reserve encompasses 98,827 ha of terrain ranging from large, flat dambo areas to the higher elevations in the Dzalanyama mountain range. The ranch includes all of this area with the exception of the highlands, totaling at 66,574 ha.

Dzalanyama has a history of boundary changes and requests for land from local chiefs, estates, and the Malawi Young Pioneers (MYP). In its early years, relocation of villages was a priority, the last of which was moved by 1931. In recent years conflicts have arisen over cattle grazing, fuelwood extraction and charcoal production. In addition, the African Development Bank (ADB) has studied the potential for privatization of grazing rights within different portions of Dzalanyama Ranch. The Lilongwe Forestry Project has studied the possibility of organizing stakeholders including local chiefs, the Lilongwe Water Board, the Ranch, and the Department of Forestry in order to engender sustainable use of the diverse resources within Dzalanyama Forest Reserve. The TA's affected include Chiefs Chiseka, Pemba, Chikulamawendo and Kalolo.

4.5.5 Vwaza Wildlife Reserve

Historically, part of the area today known as Vwaza Wildlife Reserve was originally constituted in 1941 as Lake Kazuni Game Reserve to protect the lake and its fishes. Lake

Kazuni was degazetted in 1950. However, by 1956, another large portion of land in the area was declared a Controlled Hunting Area as part of the tsetse fly control measure. This land base was extended in 1977 when the Game Reserve was officially constituted, and then renamed a Wildlife Reserve (with a land area of 98,214 ha) under the 1992 Act. The rationale behind this decision was to protect a wetland deemed of international importance and its associated examples of Malawi's biotic environment.

Vwaza has a long history of trade related to wildlife, particularly in ivory, dating back to the 18th century. Though illegal today, this trade continues and the populations of large mammal species are in decline. For example, elephants, thought to number over 250 in 1985, have declined to the point that recent attempts to assess their numbers have been unsuccessful due to limited sightings. Locally, the explanation for the decline involves relative ease of access for poachers crossing at remote points along the Zambian border, though there is evidence of hunting activity originating in Malawian communities as well.

Access to fish and large game is not the only source of conflict in Vwaza. By 1984, a number of villages were relocated out of what is now reserve land to areas just outside the boundary. These villages were placed adjacent to land already allocated to neighboring Chiefs, making access to land for cultivation problematic for the new arrivals. This has been seriously exacerbated by the conversion of large areas of customary land to estates. In a number of cases, estates have been successfully registered within the reserve, fueling requests for the location of the protected area boundary to be revised. In 1980, so a request resulted in the creation of tobacco estates instead of the intended expansion of customary land. The ancestral claims to land within Vwaza have led to heavy political pressure to reconsider the tenure status of the reserve.

Another source of tension has been public response to protection strictly through enforcement. In an effort to address this and the demand for resources, DNPW has permitted a number of villages along the southern boundary to create natural resource committees based on CBNRM principles. PLUS rapid appraisal results indicated that villages participating in this program, which is designed to permit utilization of reserve resources, have more positive attitudes towards DNPW than those outside the pilot program. They are also more motivated to implement self-enforcement of resource extraction volume limits based on sustainable use. This program currently involves communities in the areas of Chief's Mpherembe and Makwakwa with potential expansion to those under Chief's Chikulamayembe and Katumbi.

5. NATURE OF THE RESOURCE

5.1 Agricultural Suitability

Questions about the agricultural suitability of pieces of land have been frequently raised during debates on land reform policy. Through the Land Resources Evaluation Project (LREP), Malawi has a highly detailed database on the fundamental characteristics that define the potential for crop growth.[42] PLUS used this database and associated methods to model agricultural suitability for the Level 2 sites. The results from this model, when combined with erosion hazard modeling (see section 5.2) provide insight into the environmental suitability of these protected areas

5.1.1 Agricultural Suitability Model Design

The parameters that were used to calculate agricultural suitability for PLUS were similar to those applied to ELUS and very similar to those used in CLUS. As in both these studies, LREP data were used,[40] however, generalized ranges for each parameter across all crops determined agricultural suitability. See Figure 15 for model details and factors.

Land characteristics considered were wetness, slope, ponding, drainage, soil depth, and surface stoniness. *Sufficient wetness* was estimated using the length of the growing period; *shallow slopes* were defined as those less than 13%. Also, four soil characteristics defined agricultural suitability in PLUS: well drained, moderate to deep soils, and lack of surface stoniness were considered suitable soil characteristics for agriculture. These characteristics were defined using the LREP soils parameters: *soil depth*, *surface stoniness*, *drainage*, and *ponding*. The LREP agro-climatic data provided the *length of the growing period* for the five Level 2 sites. All criteria for the agro-climatic characteristic and each soil characteristic had to be met for an area to be considered suitable for agriculture. In addition to the five input layers listed in Table 12 and depicted in the maps on Figures 16-20, soil group (soil taxonomy) and texture were also used.

Table 12. Input layers for LREP agro-climatic and soils/physiography databases.

Parameter	LREP codes	Values for Agricultural Suitability
lgp (length of growing period)	2-10	120 - 270 days
slope (LREP slope class)	1-3	0 - 13% (flat to sloping)
depth (soil depth)	3-5	≥ 50 cm (moderately to very deep)
stone (surface stoniness)	1-2	non-stony/rock to stony/fairly rocky
drain (drainage)	7-9	moderately well to well
pond (ponding)	1-3	none to slight/moderate

Figure 15. Agricultural suitability model.

Figure 16. Agricultural suitability model inputs for Mulanje.

[42] Eschweiler, J.A., Paris, S., Venema, A.J.M., Lorkeers, and Green, R.I. 1991. Methodology for land resources survey and land suitability appraisal. Field Document No. 30. Land Resources Evaluation Project, Malawi Government Ministry of Agriculture, Land Husbandry Branch; UNDP; FAO.

Figure 17. Agricultural suitability model inputs for Zomba-Malosa.

Figure 18. Agricultural suitability model inputs for Liwonde.

Figure 19. Agricultural suitability model inputs for Dzalanyama.

Figure 20. Agricultural suitability model inputs for Vwaza.

5.1.2 Agricultural Suitability Model Results

Table 13 and Figures 21-25 summarize the model results and distribution of agricultural suitability for the five Level 2 sites. The results for the more mountainous areas like Zomba-Malosa and Mulanje are fairly intuitive as the steep slopes dominate all other variables that influence crop potential. In the case of Liwonde as well as some of the unsuitable areas of Dzalanyama and Vwaza, soils characteristics proved to be the most important limiting constraints.

Table 13. Agricultural suitability model results for Level 2 sites.

Protected Area	Suitable for Agriculture (Percent of Total Land Area)	Not Suitable (Percent of Total Land Area)
Dzalanyama	89.7	10.3
Vwaza	63.0	37.0
Liwonde	17.0	83.0
Zomba-Malosa	8.0	92.0
Mulanje	2.7	97.3

Agricultural suitability analysis is based largely on determining the presence or absence of the physical factors necessary for specific crops to grow. In the case of PLUS the crop-specific ranges were generalized for each factor to include suitable ranges for the majority of the 20 crops examined in LREP. Environmental hazards were not considered unless they inherently limited crop yield potential. For example, although *slope* can limit the potential for crop growth, it has a more important influence on the risk of erosion. Agricultural suitability focuses on the potential for crop production without necessarily capturing potential risks of soil loss that may be associated with it. For this reason, PLUS also modeled the soil erosion hazard (section 5.2) for the five Level 2 sites and then later coupled this with agricultural suitability to obtain environmental suitability (section 5.3).

For this reason, the high percentage of land that is suitable for agriculture in Dzalanyama and Vwaza should not be considered in isolation of other factors that may impact overall suitability. Beyond erosion hazard, other issues not linked to crop potential can be equally important in the decision making process. For example, Dzalanyama provides the catchment protection for over 30% of the watershed that serves the urban drinking water supply for Lilongwe. To account for impacts on that water supply that might be consequences of agricultural expansion into the reserve, factors beyond agriculture and soil loss (such as sedimentation rates, evapo-transpiration, etc.) would have to be added to the model.

Figure 21. Agricultural suitability model results for Mulanje.

Figure 22. Agricultural suitability model results for Zomba-Malosa.

Figure 23. Agricultural suitability model results for Liwonde.

Figure 24. Agricultural suitability model results for Dzalanyama.

Figure 25. Agricultural suitability model results for Vwaza.

5.2 Erosion Hazard

While agricultural suitability modeling focuses on crop potential, the analysis of erosion hazard addresses the idea of land suitability from the viewpoint of risk. To enhance such an analysis, it is essential to evaluate alternative land cover scenarios to better understand the erosion hazards associated with the changes in land tenure changes that may be envisioned. For protected areas in particular, this perspective is critical because changes in land tenure where native vegetation is dominant are almost always associated with changes in land cover. If the factors associated with erosion are impacted by the change, the risk of soil loss will increase.

For both the National-Level and Level 2 Erosion Hazard Model and subsequent Environmental Suitability Model, PLUS analysts calculated the erosion hazard for the present day conditions (based on 1994 land cover) and for three alternative scenarios. The objective in using the scenarios was to analyze changes that might occur with changes in land use. The Present Cover Scenario used land cover maps derived from Thematic Mapper (TM) satellite imagery to estimate erosion under vegetation conditions from 1994. This scenario represents present conditions.

The *Bare Soil Scenario* assumed complete clearing of the present vegetation cover for some other kind of land use. This scenario is also analogous to the ground conditions at the beginning of the growing season when the crops are immature; lacking a protective cover to prevent accelerated soil erosion by rainfall.

Two agricultural scenarios proposed by LREP were also modeled. The subsistence farming methods used throughout most of Malawi were modeled in the Traditional Management (tm) agriculture scenario. In this scenario only minimal erosion control measures are in place. Under the Improved Traditional Management agricultural scenario (itm), well aligned cultivation ridges and other mechanisms are assumed to be in place to control soil erosion.

5.2.1 Erosion Hazard Model Design

The erosion hazard model (Figure 26) is based on the modified Soil Loss Estimation for Southern Africa (SLEMSA).[43] Land Cover derived from the classification of Landsat Satellite Thematic Mapper data was used to estimate the *energy interception (I)* for the Crop Ratio (C) in the model. *Energy interception* is a measure of how well the ground surface is protected from rainfall or how much energy is kept from the soil when the rainfall is intercepted by vegetation or debris.

Figure 26. Erosion hazard model.

LREP Agro-climatic digital maps and database provided the average annual precipitation used in PLUS to estimate rainfall energy. Mean seasonal *rainfall energy (E)* is a measure of rainfall erosivity. The digitized LREP Soils/Physiography Map and relational database provided soil group, soil texture, and soil depth information collectively used to estimate *soil erodibility (F)*. Erodibility and erosivity combine to obtain the Soil Loss (K) factor measured in metric tons per hectare per year.

To capture the influence of topography, a Digital Elevation Model (DEM) was generated from digitized 250 foot contours from the 1:50,000 scale Survey Sheets (200 foot contours in the case of Mulanje Forest Reserve). *Slope steepness (S)* in the form of percent slope was derived from the DEM and *slope length (L)* was an estimated constant. These were used to calculate the Topographic Ratio variable.

The final output was generated by multiplying C*K*X to obtain Z, Erosion Hazard (Equation 1).

Equation 1. Modified SLEMSA

$$\text{Erosion Hazard} = Z = C * K * X, \text{ where}$$

$$C = \text{for } I \le 50, \exp(-0.06*I), \text{ for } I > 50, (2.3-0.01*I)/30$$
$$K = \exp(2.884-8.1209*F+\ln(E)*0.4681+0.7663*F))$$
$$X = \text{sqrt}(L)*(0.76+0.53*S+0.076*S^2)/25.65$$

The erosion hazard model considers vegetation cover, climate, soils, and topographic characteristics. The control variables used as inputs are *energy interception, rainfall energy, soil erodibility, slope steepness* and *slope length* (Figures 27-31). *Energy interception* levels ("I values") were assigned to each of the 1994 land cover classes derived from unsupervised digital classification. The "I values" were estimated and assigned according to data collected during the resource assessment on eight plots in four

[43] a) Elwell, H.A. 1978. Modeling soil losses in Southern Africa, Journal of Agricultural Engineering Research 23:117-127.
b) Elwell, H.A..1981. A soil loss estimation technique for Southern Africa. *in* R.P.C. Morgan, ed., Soil Conservation: Problems and Prospects. Chichester: John Wiley and Sons.
c) Paris, S., 1990. Erosion Hazard Model (modified SLEMSA). Field Document No. 13 (second version). Land Resources Evaluation Project, Malawi Government Ministry of Agriculture, Land Husbandry Branch; UNDP; FAO.

locations in each of the five Level 2 sites. These factors included *percent canopy cover, understory vegetation* and *ground cover* associated with each land cover class. Table 14 lists the energy interception values based, based on Equation 1, where on soil, cropped land and natural grassland, I $\leq$ 50%, and on all other cover classes, where I $\geq$ 50%

Table 14. Present cover erosion hazard scenario: energy interception (I) values assigned for land cover classes.

Land Cover Class	I value	Land Cover Class	I value
Broadleaf Forest	100	Dambo/Waterlogged Area	70
Evergreen Forest	100	Marsh Vegetation	70
Mixed Forest	100	Mtwatwa Thicket	65
Riverine Forest	100	Thicket	65
Moist Hilly Woodland	100	Grassland	50
Pine Plantation	100	Grassland/Predominantly Agriculture	50
Eucalyptus Plantation	95	Grassland/Soil	50
Miombo Woodland	95	Herbaceous Vegetation/Soil	50
Tea Estate	95	Predominantly Agriculture	35
Mopane Woodland	90	Soil	5
Open Miombo Woodland	90	No data	not analyzed

Figure 27. Erosion hazard model inputs for Mulanje

Figure 28. Erosion hazard model inputs for Zomba-Malosa.

Figure 29. Erosion hazard model inputs for Liwonde.

Figure 30. Erosion hazard model inputs for Dzalanyama.

Figure 31. Erosion hazard model inputs for Vwaza.

Land cover classes designated as shadow, outcrop, water, or "unclassified" due to cloud cover or cloud shadow in the satellite images were assigned to a "no data" class for all scenarios and were not included in the analysis.

Under the assumption that the three scenarios model different conditions associated with agriculture, appropriate I values were used according to LREP guidelines. For vegetated areas, these were I=45 for the itm scenario and I=35 for the tm scenario. To represent the lack of any rainfall interception, the I values were set at 0 for the bare soil scenario for all classes. *Rainfall energy (E)* is derived from the mean annual rainfall (PAN) obtained from the LREP agro-climatic map and associated database. Three classes were used for mean annual rainfall: <800 mm, 800-1200 mm and >1200 mm. A relationship between mean annual rainfall and mean seasonal *rainfall energy* (E) exists and was documented for Malawi by LREP.[44] Three appropriate rainfall classes were determined from the graphs:

[44] Paris, S., 1990. Erosion Hazard Model (modified SLEMSA). Field Document No. 13 (second version). Land Resources Evaluation Project, Malawi Government Ministry of Agriculture, Land Husbandry Branch; UNDP; FAO.

Table 15. PAN versus rainfall energy for Malawi.

PAN (mm)	Mean Seasonal Rainfall Energy (E) (Joules/ m^2)
<800	15,077
800-1200	18,846
>1200	22,615

The *soil erodibility (F)* factors for identified by LREP for the soil group data assigned to their Soils and Physiography map series[42]. The soil groups for the Level 2 sites were drawn from the associated relational database and integrated into the model.

The Topographic Ratio consists of two parts, *slope steepness* and *slope length*. Slope steepness was derived from the Level 2 DEMs for each protected area. Slope length was not calculated directly. Instead, a constant was estimated for each scenario to simulate differences in management practices. The slope lengths for the Present Cover, Bare Soil, tm, and itm scenarios were set at 10m, 30m, 20m, and 10m respectively. The shorter the slope length, the shorter the distance rainfall travels on the surface, thereby causing less erosion hazard.

After applying the erosion hazard model inputs spatially and performing the modified SLEMSA calculations, thresholding of erosion rates was performed to create suitability ratings for different erosion hazard levels.[42] The thresholding used soil depth as well as erosion rate to determine four erosion hazard classes. These classes and their LREP designations are: acceptable or highly suitable (s1), moderate or moderately suitable (s2), hazardous or marginally suitable(s3), and extreme or not suitable (n) for each scenario.

Only the first class is considered an acceptable rate or erosion for sustainable cultivation. In section 5.3, erosion hazard maps were overlaid with agricultural suitability maps. Acceptable erosion is considered “environmentally suitable” if it occurs on land suitable for agriculture. The other three erosion categories (moderate, hazardous, and extreme) were aggregated, as all three are considered environmentally unsuitable..

5.2.2 Erosion Hazard Model Results

For each Level 2 protected area, PLUS analysts produced a suite of four maps, one for each erosion hazard scenario (Figures 32-36). The percentage of total reserve land area taken up by each class of erosion for all four scenarios is summarized in Table 16. The “no data” class includes areas which could not be modeled such as rock outcrops, very rocky soils, water areas, and portions of the reserve for which land cover information was unavailable. The latter is due to the problem of small portions of cloud cover in some of the satellite imagery used to create the 1994 land cover maps (see Chapter 8).

A comparison of the Present Cover and the Bare Soil scenarios provides the greatest contrast; large areas which have acceptable erosion risk under current conditions would be heavily impacted under bare soil conditions like those which occur during bush clearing for cultivation. These conditions are also prevalent at the beginning of the growing season, particularly where dry season fires have cleared most of the residue and weeds remaining from the previous year.

Even under Traditional Management, erosion hazard is still great where there are steep slopes. In some cases, soil loss can be reduced when Improved Traditional Management practices are put in place, as can be seen by comparing the tm and itm scenarios for Dzalanyama and Vwaza. The same effect does not occur in either Mulanje or Zomba because the slopes are simply too steep.

Table 16. Erosion hazard model results.

	Present Cover	Bare Soil	Traditional Management	Improved Traditional Management
	---(percentage of total land area)----			
Mulanje				
Acceptable	**7**	**0**	**1**	**5**
Moderate	8	0	1	7
Hazardous	6	0	2	6
Extreme	22	43	40	26
No Data	57	57	57	57
Total	100	100	100	100
Zomba				
Acceptable	**10**	**0**	**2**	**7**
Moderate	7	0	2	6
Hazardous	6	0	2	5
Extreme	69	92	86	74
No Data	8	8	8	8
Total	100	100	100	100
Liwonde				
Acceptable	**87**	**0**	**82**	**87**
Moderate	0	0	4	0
Hazardous	0	19	1	0
Extreme	0	69	2	1
No Data	12	12	12	12
Total	100	100	100	100
Dzalanyama				
Acceptable	**80**	**0**	**44**	**76**
Moderate	7	0	19	8
Hazardous	4	5	9	4
Extreme	7	93	26	10
No Data	3	3	3	3
Total	100	100	100	100
Vwaza				
Acceptable	**89**	**1**	**77**	**88**
Moderate	1	4	7	1
Hazardous	0	24	3	1
Extreme	0	61	4	1
No Data	9	9	9	9
Total	100	100	100	100

NB: "No Data" refers to non-soil areas, or areas that had no cover information (i.e. clouded portions of satellite images from which cover maps were made).
Only ***"acceptable"*** *erosion satisfies the suitability analysis criteria, hence is in* ***bold****.*

Figure 32. Erosion hazard model results for Mulanje.

Figure 33. Erosion hazard model results for Zomba-Malosa.

Figure 34. Erosion hazard model results for Liwonde.

Figure 35. Erosion hazard model results for Dzalanyama.

Figure 36. Erosion hazard model results for Vwaza.

5.3 Environmental Suitability

5.3.1 Environmental Suitability Model Design

The Environmental Suitability Model used by PLUS is a spatial merging (Boolean intersection) of the results from the Agricultural Suitability and Erosion Hazard Models. Eight initial categories result: suitable and not suitable for agriculture for each of the four levels of erosion hazard. This can be simplified to two classes because three of the four erosion hazard classes pose unacceptable risk, while only the fourth is acceptable. The result of such a simplified merging provides a binary map: areas classed as suitable for agriculture with an acceptable erosion risk are considered "environmentally suitable."

Any land that is considered unsuitable for agriculture or is subject to unacceptable erosion under traditional management would be considered "not environmentally suitable." The "environmentally unsuitable" class includes areas that do not support cultivation under the scenario conditions or that have erosion hazards that are moderately severe to severe. The combination would make sustainable agriculture impossible, or pose unacceptable levels of erosion hazard.

5.3.2 Environmental Suitability: Beyond the Focus on Erosion

The criteria used for this analysis are based on the recommendations of the Lands Steering Committee that the focus be on agriculture. This was decided because agriculture is the most important form of sustenance in rural Malawi, and is the driving force behind land demand. However, it became very clear at the PLUS Closing Seminar that once agricultural suitability has been ascertained, the focus moves on to other environmental issues. Concern over erosion hazard is often raised because of the potential impacts on lake sedimentation rates and the associated Shire River flows that generate Malawi's electricity. To assess the impact of land tenure change on sedimentation rates would require additional data layers that currently are unavailable (i.e. stream flow data and higher spatial and temporal resolution precipitation analysis).

Other issues raised during the seminar included impacts to biodiversity and wildlife habitat, and concerns over Lilongwe's urban water supply. All of these issues can be analyzed using similar modeling techniques employed by PLUS to ascertain agricultural suitability and erosion hazard. The only limitations are digital spatial data appropriate to the environmental question, and the capacity to allocate technical resources from appropriate government agencies to conduct the analysis.

PLUS introduced environmental suitability modeling with a focus on agriculture and erosion in response to the Lands Steering Committee. Since that time, six government agencies interested in environmental problem solving have come together under the umbrella of the Malawi Environmental Monitoring Program to design a prototype environmental information system to respond to new questions. As part of the design of that EIS, they requested that PLUS structure the entire GIS data set to be easily integrated into the prototype. The first test of these efforts will be in the analysis of issues faced in the Middle Shire related to erosion and stream sedimentation.

5.3.3 Environmental Suitability Model Results

The results of the Environmental Suitability Model are presented as percentages of land suitable and unsuitable for the three alternative scenarios (Table 17). They are also presented graphically for each Level 2 protected area (Figures 37-41). Only 1% of the agriculturally suitable land in the Mulanje Forest Reserve is environmentally suitable. For Zomba-Malosa Forest Reserves only a fraction of the 8% area that was determined to be suitable for agriculture was environmentally suitable due to unacceptable erosion hazard. In the case of Liwonde National Park agriculturally and environmentally suitable areas remained the same in the tm agricultural scenario and by employing the itm Agricultural Scenario there was only a 1% increase in environmentally suitable land. There is a large area along the east central section of the park that experienced negative change due to encroachment (see Chapter 8) which proved to be environmentally suitable. Dzalanyama Forest Reserve is 90% suitable for agriculture but only 51% is environmentally suitable based on the erosion hazard under traditional management. Vwaza Wildlife Reserve showed far less dramatic differences where 58% of the land was estimated to be agriculturally suitable and 53% environmentally suitable under the tm scenario. As would be expected in all five Level 2 sites, the bare soil scenario eliminated virtually all land from being environmentally suitable with the exception of 23% of Vwaza.

Table 17. Environmental suitability model results with alternative cover scenarios.

		Bare Soil	Traditional Management	Improved Traditional Management
		--(percentage of total land area)--		
Mulanje Forest Reserve	Not Suitable	100	99	97
	Suitable	0	1	3
Zomba-Malosa Forest Reserves	Not Suitable	100	99	97
	Suitable	0	1	3
Liwonde National Park	Not Suitable	95	83	82
	Suitable	5	17	18
Dzalanyama Forest Reserve	Not Suitable	96	49	23
	Suitable	4	51	77
Vwaza Wildlife Reserve	Not Suitable	77	42	32
	Suitable	23	58	68

These results highlight the risks associated with clearing land for cultivation. This is true even after a crop has taken seed and is providing some cover; erosion risks remain high. They also suggest that in areas where land is close to the threshold of suitability (particularly in lowland areas of Vwaza and Dzalanyama), improved management practices focused on erosion control can make a large difference in limiting soil loss and raising the potential for agricultural production.

However, these results *do not* cover factors beyond those that address crop potential and erosion hazard. Every protected area is unique and faces unique land use issues. Land that is environmentally suitable where the only concerns are agriculture and erosion will not necessarily be suitable where protection of wildlife or water supply are critical (i.e. Vwaza and Dzalanyama.

Figure 37. Environmental suitability model results for Mulanje.

Figure 38. Environmental suitability model results for Zomba Malosa.

Figure 39. Environmental suitability model results for Liwonde.

Figure 40. Environmental suitability model results for Dzalanyama.

Figure 41. Environmental suitability model results for Vwaza.

6. PRESSURE ON THE RESOURCE

Pressure on protected area land and resources comes from a variety of sources. While Chapter 7 analyzes land and resource utilization needs of communities adjacent to protected areas, it is also possible to gain insight into the potential pressure coming from adjacent population as well as limits to that pressure due to limited access to the land. These may be examined by modeling both on a more macro scale. Population pressure is something that can be quantified by the number of people, though such an analysis done in isolation will say nothing about their ease or difficulties in gaining access to a protected area, or their impact on that area over time. Access can also be modeled if the key associated variables can be mapped. Together, measures of potential population pressure and the limits or lack of limits that population has on resources within the reserve provides a better understanding of the pressure faced by protected areas in Malawi.

6.1 Population Pressure

The Potential Population Pressure Models were analytic tools developed to allow an assessment of potential human pressure on the five Level 2 sites. These results provide an indication of possible impetus for land conversion. There are two population models: *direct* population pressure on protected areas, and *potential* population pressure (Figure 42). The former measures the total population within five kilometers surrounding the protected area. The latter considers the density of that population relative to its distance from parts of the protected area; this is essentially an assessment of the potential pressure it may have on each point within the reserve. Neither model assesses any aspect of access or impact the population may have. However, both of these concepts are addressed later in the document (section 6.2 and 8.3, respectively). In addition, the results of this model are overlaid with the analysis of land cover change in Chapter 8 to help identify areas where population and change are related, and areas which may expect to see change in the future due to higher pressure. These areas are shown as zones of high *potential* pressure.

Both models were based on the 1987 Malawi census data provided by FEWS for each Extension Planning Unit (EPA)[45] because this was the smallest area measure of population that was spatially available. There are 154 EPAs, averaging 600 km^2 in size with 74,000 people in each. Though EPA-level population density is much more detailed than district-level (often used in population studies), its use here still requires the assumption that population is evenly distributed throughout the EPA.[46] The impact of this assumption is that detail beyond the EPA level cannot be captured, and in some cases the affect of heavy population concentrations might be smoothed.[47]

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[45] Mornière, L., Weiss, E. and Chimwaza, S. 1996. A Quest for Causality: Vulnerability Assessment & Mapping (VAM), Malawi Baseline 1996. WFP;GOM:FEWS, Lilongwe.

[46] If, for example, census data were aggregated to the village, estate and urban neighborhood, and then the boundaries of these areas were mapped and digitized, the spatial resolution of population density would be considerably better than EPAs.

[47] It should also be noted that after the population models were complete, PLUS discovered what appeared to be anomalies, particularly around Zomba-Malosa Forest Reserves. Upon consultation, it was discovered

Figure 42. Population pressure model.

Because some EPAs include land within protected areas, it became necessary to adjust the model for the zero (or extremely low) population density within parks and reserves.[48] For affected EPAs, population density was recalculated for the land area outside the protected area boundary (EPA land area less any protected land within the EPA boundary). Finally, the results of the PLUS rapid appraisal indicated that use of resources on protected area land by local communities declines sharply at a distance of five kilometers from the boundary. Therefore, only populations within a five kilometer buffer around the protected areas was considered in the models.

6.1.1 Direct Population Pressure Model Design

Direct population pressure was defined as the number of persons within five km of a protected area. For each protected area, the surrounding five km buffer was selected, and the total number of persons within the buffer was found by multiplying the area of each partial EPA within the buffer by the recalculated population density, then summing results for the buffer. Again, these calculations assumed that the population was uniformly distributed throughout the unprotected area of the EPA. The result is a single value for direct population pressure that can be applied to the protected area. This aids in understanding the pressure related to a specific park or reserve, but is not useful in comparing two protected areas of different size. It also does not consider the issue of distance between the population and each point within the protected area that those people could potentially influence. For these reasons, a second model was necessary.

6.1.2 Potential Population Pressure Model Design

Potential population pressure was defined as the number of persons within five km of each *point* inside a protected area who could all potentially have access to that point[49]. The value of potential population pressure varies with the distance from the boundary of the protected area, and therefore must be represented spatially as a grid. This measure has different values for different points within the protected area. By definition, points inside the protected areas at a distance of more than 5 km from the boundary will show zero *potential* population pressure.

For input to the model, a grid made up of cells (30 x 30 meters) was placed over a digital map of the protected area and its five-kilometer population buffer. Within each

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that urban population was not included in the FEWS, EPA density maps. Ideally, if time had permitted, these figures would have been added to represent rural and urban population pressure, combined.

[48] Some protected areas have very small populations within their boundaries while others have experienced encroachment. The effort to exclude protected area land from the density analysis does not ignore these possibilities, but rather, it places any internal population theoretically outside the boundary so that it can be evaluated as a contributor to that overall pressure. If this were not done, some EPAs would show a lower density (and thus lower pressure) than actually exists because it would be spread across land with very few inhabitants.

[49] Again, the focus is here is only on potential pressure relative to distance. Issues such as ease of access due to location of paths or roads, steep or gradual slopes, or boundary restrictions are addressed in section 6.2 on Access. Utilization of resources is addressed in Chapter 7, and impact derived from land cover change detection is addressed in Chapter 8.

population buffer cell, the population density of the individual EPA was recalculated from the number of persons per square kilometer to number of persons per 900 square meter cell. The density was then converted back to numbers of persons per cell so that they could be tallied at a later step. For areas within a protected area, population was assumed to be zero while inside the five km buffer, population varied by EPA.

Next, a potential pressure value was calculated for each cell inside the protected area through a five kilometer circular neighborhood function that totaled population within that radius from the protected area cell. For cells close to the protected area boundary, adjacent population greatly affects the total potential pressure. For cells deep inside a reserve, little or no population may be within 5 km, producing little or no potential pressure on those cells.

6.2 Access Model

Population does not only affect the potential pressure on public land resources but also the accessibility to resource utilization areas. Proximity to tracks or roads, and impediment caused by surface ruggedness all might serve to ease or inhibit accessibility to an area. In addition, protection through government agency monitoring along the boundary can also deter access. To understand what these factors might contribute to understanding the pressure on a given protected area, PLUS analysts simulated how these variables might limit access to protected areas.

6.2.1 Access Model Design

The Access Model is based on the use of a spatial modeling technique designed to create "friction" or "cost" surfaces. Traditionally they have been used for helped identify the best route for a new road or path by identifying geographic features which might physically inhibit movement along the route. Once identified, these features are digitally mapped and each is assigned a difficulty factor. When taken all together, attempts at plotting the new road or path are directed away from areas which have higher "difficulty." In the case of the PLUS Access Model, features that were digitally mapped and available that could ease or restrict access were roads, paths, and the ruggedness of the surface (i.e. steep slopes). The boundary of the protected area also proved useful as a proxy for protection efforts in the form of forest guard or wildlife scout monitoring.

The access model has two scenarios: the Restricted Access scenario assumes that roads and tracks provide the only routes into and through the protected area, and the Unrestricted Access scenario assumes that the protected area boundary is open and provides additional means of access (Figure 43). The Restricted Access Model assumes there are protection mechanisms in place at the park or reserve boundary such as fences, guard posts, or surveillance activities by scouts. Distance from access sources (roads, tracks, and boundaries) and topographic difficulty are factored into the model along with the restrictive protected area boundary.

Inputs to the models include routes of access (roads and tracks, presence or absence of boundaries as an impediment to access), percent slope and elevation (derived from the DEM) for each Level 2 site. The results of the access models reflect the relative difficulty of moving across the landscape. Population figures for Malawi only were evaluated;

protected areas that border with neighboring countries were analyzed for only the internal Malawi boundary areas. At Level 2, this affects Dzalanyama's shared border with Mozambique and Vwaza's shared border with Zambia. Population pressure results were classified relative to a mean value calculated for all the protected areas of Malawi. If a cell had a value greater than the mean, it was reported as "above the national average" and if it was less, "below the national average."

Figure 43. Access model.

6.2.2 Potential Population Model Results

PLUS analysts defined a standard against which the quantitative results of the potential population pressure modeling could be compared. This standard was based on the average potential population pressure for all cells within all protected areas in the entire country. The value of the standard was calculated by running the model at the national scale. All reported results above that mean were considered "above the national average" and all that were less were considered "below the national average." The five Level 2 sites ranged from 0% of areas facing above average pressure in Vwaza to 19% in Mulanje (Table 18). The spatial representation of that pressure is available in Figures 44-48.

Table 18. Potential population pressure model results.

	Percent of Land Above the National Average	Percent of Land Below the National Average
Mulanje	19	81
Dzalanyama	16	84
Liwonde	2	98
Zomba-Malosa	1	99
Vwaza	0	100

The zones of pressure for all of the reserves except Zomba agreed with qualitative information gathered during the rapid appraisal conducted in 1996 and early 1997. The northern region in general is noted for much lower population densities than the central or southern regions and the results for Vwaza did not differ. Likewise, very high population concentrations exist in some districts in the central and southern regions, including Mulanje and Phalombe (which include the Mulanje Forest Reserve), and Lilongwe and Dedza (which include most of Dzalanyama). These two reserves show much more land under pressure above the national average than the other three.

Zomba-Malosa proved to be anomalous due to urban population figures, which are not part of the FEWS EPA population density mapping (see footnote 47 on page 83). Unfortunately, this anomaly in the data set was not discovered until late in the analysis phase and thus could not be adjusted in the model prior to report completion. However, the prototype EIS efforts on the Middle Shire may use a similar pressure model that could be modified to include the urban figures. This issue had much less impact on the other protected areas because either the urban centers were too far from the boundary to impact the results or they were small enough to have only a minimal effect (i.e. Mulanje, Phalombe, Liwonde).

PLUS analysts were able to manually add Zomba urban figures to the tabular data. This would effectively double the population in the corresponding Thondwe EPA, hereby showing the southwestern boundary of the reserve to be under higher population pressure than all others. Unfortunately, this could not be done for the spatial analysis. This should be taken into consideration when reviewing the Zomba figures in Table 18 and the population pressure map in Figure 45.

Figure 44. Population and access model results for Mulanje.

Figure 45. Population and access model results for Zomba-Malosa.

Figure 46. Population and access model results for Liwonde.

Figure 47. Population and access model results for Dzalanyama.

Figure 48. Population and access model results for Vwaza.

6.2.3 Access Model Results

Access to highly mountainous reserves such as Mulanje, Zomba and western Dzalanyama was shown to be very difficult due to the inhibiting effect of the steep slopes (Figures 44, 45 and 47). The flat areas such as the lowlands of Liwonde and Vwaza were most accessible (Figures 46 and 48). This was due to the affect of slope and elevation factors that combined to simulated terrain ruggedness. The assumption of easier access provided by roads is evident in both scenarios (free vs. restricted access), but is more pronounced in the restricted model. Also inn the restricted model, the effect of the boundary as a deterrent to access forced access to be via transportation routes; therefore accessible areas were congregated along roads and tracks. Without this restriction, the outer edge of each reserve or park was most accessible (except where slopes were prohibitively steep or the terrain was extremely rugged).

6.2.4 Population Pressure and Access Combined

Results from the Access Model results were subsequently combined with the Potential Population Pressure Model results to form the Pressure on the Resource Model (not depicted here – see Figures 64-68 in Chapter 8). In Dzalanyama access is easiest in the high potential population pressure belt (Figure 67), primarily due to the higher concentration of reserve maintenance roads, low elevations and the gentle topography. By contrast, in Liwonde (Figure 66) no mapped roads or tracks are near the high potential population area in the northeast. Almost the entire area mapped as having high potential population pressure was in an area of low accessibility, resulting in a reduced likelihood of overall pressure.

In the Mulanje Forest Reserve, the high population pressure areas are located along the borders, particularly to the south and east (Figure 64). In the unrestricted scenario, most of the border areas are highly accessible except where the slopes are precipitous as in the southwest corner of Mulanje. Easy access and high population pressure do not always correspond in Mulanje, due to very steep slopes and the location of roads.

Similar results occur in Zomba (Figure 65), but these are influenced by the missing urban population count, particularly along the southwestern edge where roads are near Zomba urban population concentrations. If these had been available for the analysis, the highest concentrations of people would not have occurred on the western boundary of the reserve.

7. COMMUNITY-LEVEL RESOURCE UTILIZATION

As the previous chapters have indicated, a significant population resides around the borders of Malawi's protected areas. In some cases, these communities occupied the public forests and reserves prior to their creation; in other cases, they have been forced up against reserve boundaries by population pressure or by the usurping of neighboring lands by the estate sector. In either instance, these communities are the ones that lay "claim" to the public resource, who currently use the resource, and who would likely occupy the lands should they be degazetted. In effect, the households in these communities already make use of the protected areas they abut, either officially or clandestinely, and the common property resources of these lands have already been integrated into the livelihood strategies of the local population. Since the resources of the protected areas produce for some households an economic output, it is possible to speak of a "public lands economy", which constitutes the major substance of this chapter. In the following sections, three major questions are addressed:

- **What are the socio-economic characteristics of the communities that surround the protected areas?**
- **How do these communities make use of the common property resources of the protected areas?**
- **What is the economic importance of these resources to the welfare of the surrounding communities and to the country as a whole?**

In answering these questions, this chapter defines the level of reliance, or dependence, on the protected areas and provides a more comprehensive analysis of the current complexity of land utilization and management. It distinguishes between the local component of the public lands economy, which contributes directly to the well-being of the surrounding population and the "export" component which ties the use of public lands to the wider Malawian economy.

7.1 Methodology

In order to compare the socio-economic and the biophysical characteristics in a systematic fashion, the study sample was comprised of communities abutting the same protected areas identified in the Level II analysis: Mulanje, Zomba-Malosa, Dzalanyama (all forest reserves), Liwonde National Park, and Vwaza Wildlife Reserve. In effect, it was decided that these five protected areas sufficiently represented major utilization differences as well as the principal geographical and ethnic variation found throughout the country.

For each protected area, a multidimensional methodology was developed in order to collect both qualitative and quantitative data. Two collaborative teams comprised of researchers from Arizona and Malawi conducted the research. Under the leadership of Mr. Luke Malembo from FRIM, the field teams were comprised of Chewa and Tumbuka speakers (four male and four female), and all members participated in the preparation of the qualitative and quantitative instruments for the study. The data were collected over 9 months during 1996 and 1997, beginning with a pilot study in Zomba-Malosa Forest Reserve.[50]

With regard to qualitative data collection, the research team carried out rapid rural appraisals in each of the study locations. These rapid appraisals consisted of community level, focus group, and key informant interviews designed to elicit generally shared information on village and household livelihoods, including access to infrastructure, resources, and services, and the role of public lands and resources in local livelihood systems. Community interviews focused on the history of the village and the use of public land resources for food, medicine, fuel, and construction materials, and how availability and use of such resources has changed through time. Focus group interviews collected data on village infrastructure, access to resources, and livelihood activities, including the nature of agricultural practices (crops, seasonality, land, labor, conservation strategies), livestock, other income-generating activities (such as wage labor), food stress periods and coping strategies, and patterns of public land resource use. Focus groups were conducted with separate groups of men and women in each village. In addition, over 200 key informants were interviewed on various topics during the course of fieldwork in the five study areas. The interview topics included land tenure, specialized activities involving the utilization of public land resources, urban trade in fuelwood, and bushmeat hunting and trading. Also, several market surveys were carried out for the purpose of converting local measures into kilogram weights and obtaining market prices for a wide range of both domestic commodities and public land resources. With these qualitative data gathering techniques, 138 villages were contacted during the study.

With regard to the quantitative dimensions of the methodology, 4-5 villages in each protected area were selected for a household survey that could document variations at the household level of use of protected area resources. A total of 22 villages were included in the survey sample and all were located within a five kilometer buffer zone or perimeter around the particular protected area.[51] In each of the villages, a random sample of approximately 25 households was selected for household interviews, and the final sample consisted of 552 families. Table 19 illustrates the distribution of the sample by village and protected area.

Each household included in the survey was interviewed using a formal questionnaire. This survey instrument collected information in three critical areas: the household asset base (family labor, land, and animals), access to non-agricultural income, and the detailed use of resources from the protected areas. These data were coded and entered in an SPSS (Statistical Package for the Social Sciences) program in Malawi, then analyzed at the University of Arizona. The original questionnaires are available as part of the Data Manual (see Section 4.4 for data repository details).

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[50] PLUS considered a study design that would compare villages adjacent to and distance from protected areas. The information base particular to utilization and reliance existing prior to PLUS was quite limited, suggesting a focus on villages adjacent to reserves would be necessary. It was suggested in the Closing Seminar that a) future socio-economic studies incorporate resource utilization, regardless of location, and b) a comparative study be considered by Malawi's research institutions in future.

[51] The 5 km buffer was determined during the rapid appraisal as the distance after which the major source of fuelwood and other resource ceased to be the protected area for local communities. These trials took place around Zomba Forest Reserve.

Table 19. **Socio-economic sample structure, by protected area and household type.**

Protected Area /Village	Total Sample (N)	Male-headed Households (N)	Female-Headed Households (N)	(%)
Mulanje	*127*	*90*	*37*	*29*
Nessa	27	22	5	19
Lupiya	25	19	6	24
Kambenje	25	16	9	36
Mlelemba	26	17	9	35
Kadewere	24	16	8	33
Zomba-Malosa	*125*	*80*	*45*	*36*
Chilasanje	25	16	9	36
Mbuliwa	25	17	8	32
Malemia	25	16	9	36
Mdumu	25	16	9	36
Chikanda	25	15	10	40
Liwonde	*100*	*72*	*28*	*28*
Likulungwa	25	19	6	24
Chatama	25	17	8	32
Kamwendo	25	17	8	32
Balakasi	25	19	6	32
Dzalanyama	*100*	*78*	*22*	*22*
Mthang'ombe	25	20	5	20
Kamphambanya	25	20	5	20
Tusmbi	25	18	7	28
Kanjinga	25	20	5	20
Vwaza	*100*	*75*	*25*	*25*
Mowa	25	17	8	32
Kapalala	25	19	6	24
Kapemba	25	21	4	16
Thomas Mkandawire	25	18	7	28
Totals	*552*	*395*	*157*	*28*

Much of the analysis is based upon two key operational concepts that directly address the three questions presented above. The first is that of household well being, expressed in terms of household income. In this study, income estimates from all sources (direct and indirect)[52] were compiled for each individual household and converted into per capita

[52] Direct income is the actual monetary compensation received by household members for wage labor, handicraft sales, and other income generating activities. Indirect income is the estimated market value of goods produced and consumed within the household, such as subsistence maize production.

values. Then a minimal subsistence standard was created by calculating the current market value of annual per capita maize consumption estimates. The amount of maize needed to provide a minimally viable livelihood in effect became the proxy measure of well being, even though it is recognized that households need more than maize to survive. The entire sample then was classified into four categories consisting of an interval twice the amount of the per capita maize standard and one more than twice the maize standard, then one that is one-half the maize standard and, finally, one less than one half the standard.

The second concept is that of resource use. In this case, a similar procedure was followed by establishing a standard based on annual per capita biomass consumption for the country as a whole. With this measure as a reference point, per capita biomass consumption (by household) was estimated and classified into the four categories defined by the extent that the estimated utilization is above the standard (twice, more than twice) or below the standard (half or less than half) the proxy measure of resource use. In a final step, these two classifications (income and biomass consumption) are compared to estimate different levels of reliance on the resource base.

It is necessary to further note that much of the survey analysis distinguishes between jointly-managed and female-headed households, since this latter group tends to constitute a relatively disadvantaged segment of the rural population. Approximately 28 percent of the sampled households were managed by single women, most of whom were either divorced or widowed.

7.2 Socio-Economic Characteristics of Protected Area Communities

The households residing in the communities surrounding the protected areas depend primarily on agriculture for their survival, although many supplement their income with off-farm or non-agricultural activities. As such, the two essential resources that households employ to generate their livelihood strategies are labor and land. In the following sections, each of these resources is compared across the different protected areas and across the different household types (male vs. female-headed households).

7.2.1 *Labor Availability*

As in most subsistence systems, the principal source of labor is from the family itself. Thus, the size and the composition of the household provide important insights into both the availability of labor and the consumption demands on household production. Table 20 summarizes the demographic characteristics of the households in the survey, distinguishing between jointly managed households and those families headed by women. In general, household size averages about five members. When participation in production and consumption activities of young adults and elderly family members is adjusted for,

Table 20. Demographic characteristics of Level 2 households.

these households have access to slightly over 2.5 adult equivalents, which in effect is an estimate of the available labor force. There are distinct patterns between male and female households, in that the latter tend to be smaller with less access to labor. In terms of the quality of the labor force, there are significantly fewer males in the female-headed households, which may restrict somewhat the range of activities that can be carried out by these families. The data further reveal that while the average ages for all household heads vary around the mid-forties, female heads tend to be older in all the protected areas.

7.2.2 Land Availability

The second critical resource to rural families is land, both in terms of quantity and quality. Since Independence in 1964, and particularly after 1970, land has become increasingly scarce to rural households due to pressure from explosive growth the estate lands sector and from population growth. The survey results clearly demonstrate this scarcity in the communities surrounding the protected areas. The focus-group interviews indicate that traditional authorities still maintain control over non-utilized land, but that the growing scarcity has tended to individualize land in a more permanent manner. Land sales are generally prohibited under traditional rule, so individual households acquire land either through inheritance or through borrowing from family members or emigrants. As Table 21 suggests, land is relatively more scarce in the southern regions of the country, where populations densities are much higher. This may be caused by several economic-based migrations prior to the Mozambican civil war and perhaps surges of political refugee, which came after. In the communities abutting Mulanje, Liwonde, and Zomba-Malosa, the average land size is about one hectare, and the per capita access to land is about one-fifth of a hectare. In Dzalanyama and Vwaza, toward the center and northern regions, respectively, the total land size and per capita land resources are significantly higher, but still low in absolute terms. This area is scattered over an average of about 2.5 non-contiguous plots, with a slightly lower number of plots for Liwonde (about 1.8) and substantially higher for Vwaza (about 3.6). Overall, these data strongly support a major assertion that agricultural land scarcity has reached critical levels. With regard to differences between household types, female-headed families have less area in absolute terms, but about the same amount when adjusted for family size. Thus, it is likely that the overall lack of labor restricts access to larger land areas.

Farmers generally recognize three types of agricultural plots: the larger rain-fed plots on which food crops (principally maize) and perhaps tobacco are grown, *dimba* bottomlands, which retain enough moisture to permit a wider variety of crops, including vegetables, and home gardens, which are attended more intensively and perhaps watered. In part, the number of individual plots represents a household strategy of maintaining land of different soil types and moisture retention characteristics; however, not all households have access to the richer dimba land.

The quality of land is indirectly related to land scarcity in two ways. First, high quality soils can sustain a larger population, while more marginal soils require a larger area to obtain desired production levels. Also, as population increases, the use of fallow periods to maintain soil fertility diminishes, thus contributing to the degradation of the resource base. In Malawi, as elsewhere, soil quality can vary widely across rain-fed lands, and farmers were asked to qualitatively evaluate the soil fertility of their plots, assigning a value of good, average, or poor to the area of each plot. Appendix G indicates that over the five protected areas, about 40 percent of the soil is classified locally as "poor," while about 30 percent is considered good soil. Male-headed households generally have access to more fertile soils than do the female-headed families. With the exception of Dzalanyama, the protected areas with greater land scarcity also have the poorer soils, which might suggest a process of degradation of these soils because of intensity of cultivation. For example, Vwaza has the lowest pressure on the land and the lowest percentage of poor soils, while, in contrast, Mulanje has the most critical shortage of land and the highest percentage of poor soils.

Related to the local perception of soil quality is the household effort to maintain soil fertility. In Malawi, subsidized commercial fertilizers were widely available and accessible to the customary land sector until macro-policy reforms removed the subsidy, forcing the price beyond the purchasing power of most subsistence farm families. To replace chemical fertilizer, some farmers use manure or other organic fertilizers. It is also possible to reduce erosion and soil degradation through contour ridging and other practices such as crop rotation, mounding, fallowing, etc., and the sampled households were asked to document the soil conservation techniques that they routinely employ. Appendix G reports the percentage of plots on which fertility enhancement or erosion prevention measures are applied. About 40 percent of the plots receive no specific conservation treatment, and female-headed households (who have the poorest soils) appear more likely to use conservation techniques, such as manuring, mounding, crop rotation, etc. In general, the results suggest that those household that reported higher proportions of good soil also have a higher percentage of fields with conservation measures. It is further notable that the male-headed households—having more male labor Appendix F—tend to ridge their fields, a practice that requires a higher level of heavy manual labor relative to other conservation techniques.

To summarize, the picture that these data depict is one of acute land scarcity for most of the families resident in the communities surrounding the protected areas. This lack of land requires intensive cultivation, reduction in fallowing, and the growing need for soil enhancement practices. In this context of land scarcity, the major question becomes one of sustainability, both in economic and in environmental terms. How do people survive, given this low resource endowment?   This study attempts to address this issue by documenting the production capacity of each household and estimating their dependence on off-farm sources of income.

7.2.3 Household Incomes and Poverty Estimates

Rural households in the communities sampled in this study have access to three categories of income: agricultural production, income-earning activities, and informal social assistance (gifts, remittances, sharing, etc.). In this section, the value of agricultural production—both consumed at home and sold—is combined with cash inflows from the other two sources of in order to establish an overall level of income, and from that, an overall level of poverty.

The households in this survey follow a production strategy of diversification, allocating their land and labor resources to a combination of food and cash crops. Maize is the essential subsistence crop, providing the basic staple food. Although Malawi has an

Table 21. Land characteristics, by protected area and household type.

agricultural economy based primarily on export tobacco, only six percent of these family farms grow tobacco as a cash crop. Under conditions of land scarcity, the preferred cash crops tend to be high-value, land intensive products such as fruits, vegetables, and groundnuts. On average, each household produces about six crops, with slightly less diversification in Liwonde (about four crops). Also due to the lack of land, these households do not maintain a significant number of livestock, despite the economic potential of animals. Livestock ownership patterns vary from around half the households in Mulanje (again, where land scarcity is most critical) to all the households in Dzalanyama. However, in all cases, the preferred livestock types tend to be poultry or small ruminants, both kept in small numbers. Seldom does a family have more than two different livestock types.

Overall agricultural productivity throughout the sample appears to be quite low. While it is difficult to measure total production on plots where farmers interplant multiple crops, maize is the predominant crop. Most fields have some maize, so that if total reported land is used as a proxy measure of hectares in maize, then maize yields are between 500 and 1000 kilograms per hectare (allowing for the fact that this is an underestimate proportional to the percentage of land in other crops). These estimates do not deviate significantly from national averages, and, as expected, the lowest yields again are found on those protected areas where land scarcity is greatest and soil quality is the lowest (e.g., Mulanje).

Most families cannot survive on agriculture and livestock strategies alone, and they seek income generating activities away from the farm. In this study, two categories of income producing activities are distinguished—those that require access to the protected areas and those that do not. Many families allocate some labor toward wage work (locally referred to as *ganyu*) either in agriculture (e.g., harvesting tea on estates) or in non-agricultural activities (e.g., unskilled construction labor); however, other albeit scarce employment opportunities do exist (e.g., petty commerce). Those activities that involve use of protected area resources include the sale of firewood and construction materials (poles, thatch, etc.), fuelwood for brick-making and for brewing, materials for handicraft production, wild foods for sale, hunting and fishing for sale, and so forth. Between these two categories, virtually every family has an income source during the year. In addition, a reduced number of households obtain income from emigrant remittances and from gifts and local charity; however, these amounts are not substantial. These income strategies are illustrated in Figure 49.

Table 22 summarizes the income profiles of the families in the sample. It is important to recall that the estimates of agricultural and livestock derived income include not only what is sold, but also what is consumed within the household. The data clearly show that the majority of family income is generated from the combination of agricultural and livestock production (the vast majority derived from agriculture), which in effect underscores both the local desire to expand their agricultural holdings and the general lack of non-agricultural employment opportunities. Since, however, overall income levels are so low, non-agricultural contributions, though lower, are nonetheless critical.

Figure 49. Income model.

Table 22. Average income profiles of households.

	Sources of Income Average per Capita Income per Household (MK)					
Protected Area **Household Type**	**Ag. Production**	**Livestock Production**	**Income-Generating Activities**	**Other Sources**	**Total Income (MK)**	**Ag. and Livestock Share (%)**
Mulanje	*972*	*377*	*622*	*292*	*1696*	
	N=126	*N=60*	*N=103*	*N=21*	*N=127*	*67*
Male	985	342	695	367	1789	
	N=89	N=52	N=73	N=13	N=90	66
Female	940	601	444	170	1468	
	N=37	N=8	N=30	N=8	N=37	71
Zomba-Malosa	*2217*	*236*	*1262*	*484*	*3160*	
	N=125	*N=74*	*N=97*	*N=17*	*N=125*	*70*
Male	2388	267	1372	397	3445	
	N=80	N=56	N=69	N=13	N=80	68
Female	1912	139	991	769	2653	
	N=45	N=18	N=28	N=4	N=45	75
Liwonde	1179	456	1314	625	2538	
	N=98	N=66	N=75	N=15	N=100	74
Male	1201	149	1285	1091	2394	
	N=70	N=48	N=57	N=7	N=72	71
Female	1125	1275	1405	217	2910	
	N=28	N=18	N=18	N=8	N=28	81
Dzalanyama	*1421*	*928*	*965*	*179*	*2757*	
	N=96	*N=64*	*N=86*	*N=9*	*N=100*	*76*
	1537	1036	1099	336	3112	
Male	N=77	N=52	N=67	N=4	N=77	76
	955	465	490	55	1514	
Female	N=19	N=12	N=19	N=5	N=22	78
Vwaza	*2498*	*309*	*1099*	*273*	*3857*	
	N=100	*N=87*	*N=92*	*N=29*	*N=100*	*82*
Male	2273	305	1344	219	3862	
	N=75	N=67	N=71	N=15	N=75	80
Female	3171	323	268	331	3841	
	N=25	N=20	N=21	N=14	N=25	86
Total	*1663*	*446*	*1035*	*366*	*2764*	
	N=542	*N=351*	*N=453*	*N=91*	*N=551*	*74*
Male	1675	415	1151	427	2889	
	N=389	N=275	N=337	N=52	N=393	72
Female	1633	557	701	284	2449	
	N=153	N=76	N=116	N=39	N=157	77

Table 20 summarizes the income profile of households in each protected area. The overall per capita income estimate for the entire sample is about 2750 MK, less than US$ 200; however, the median income for these households is only 1500 MK, or about US$ 100 per capita, which suggests an uneven distributional pattern. In fact, the male-headed households have a slight income advantage over their female counterparts, and women are more dependent upon agricultural shares of income. Also, there are significant differences among the protected areas. In those communities where agriculture is more productive, incomes are higher, as is the case with Vwaza and, to some extent, Zomba-Malosa. Where land is scarcer, incomes are diminished, and non-agricultural sources of income exert more importance. The significance of Table 20 is striking in that it demonstrates extremely precarious income levels of many of the households in this study as well as the urgency of their diversification strategies as a means of survival in the context of resource scarcity.

To establish accurate levels of poverty, it is necessary to compare these income profiles against a standard that offers greater validity in assessing the income positions of communities around the protected areas. To standardize per capita income levels so that households could be grouped for comparison, a 1996 per capita dietary maize requirement of 170.3 kilograms was employed.[53] This amount was then multiplied by 7.03 MK, the average value for a kilogram of maize as estimated by data provided in this study. This process resulted in a subsistence standard of 1197.21 MK per person per year. As described above, households were then grouped according to where their per capita income fell in relation to this standard. Households that *were greater then twice the standard* income were placed into one category, those who *were between the standard and twice the standard* in another, *between half the standard and the standard* in a third category, and those *less than half the standard* income were placed in a fourth category. Once households were grouped into categories, they were disaggregated by protected area, village, and by sex of household head. The results of this classification are presented in Tables 6.5 through 6.9, with the *poorest* households located in the top rows of each table.

In the case of Zomba-Malosa (Table 24), approximately 32 percent of the families lie beneath this minimal survival line, of which about 10 percent are in the poorest category. Even if income levels were severely underreported, these families clearly live at the edge of survival. There is also significant village level variation within Zomba-Malosa, with Mbuliwa in a relatively advantaged position, while Chikanda, a peri-urban settlement with little agriculture, is significantly disadvantaged. The male-headed households are slightly better positioned than the female households. In the case of Mulanje (Table 23), more than half the sample is located in the precarious categories, and one village (Nessa) has more than two-thirds of its population under the minimal standard. Almost one-quarter of the households in these communities are found in the lowest category—i.e., less than half the minimal threshold. Again, female households are worse off. A similar

[53] Johnson, J.. March, 1996. An Analysis of the Extent, Causes and Effects of Food Insecurity in Malawi, with an Approach to Improving Food Security." FAO Small Holder Agricultural Productivity Programme (SAPP), Occasional Paper #1, page 14.

despairing pattern is discerned for Liwonde (Table 25), while the households in Dzalanyama (Table 26) are marginally improved (except for the village of Tsumbi). In Vwaza, where agricultural conditions are most favorable and land is less scarce, the sample of men and women household heads are decidedly better off than the rest (Table 27). Nearly half the households are positioned in the highest of the income categories.

Table 23. Standardized income categories, Mulanje Forest Reserve.

Standardized Income	Mulanje (%)	Sex of Household Head (%)		Villages Surveyed (%)				
		Male	Female	Nessa	Lupiya	Kambenje	Mlelemba	Kadewere
Less Than Half the Standard	24.4	22.2	29.7	25.9	24.0	24.0	30.8	16.7
Between Half the Standard and the Standard	29.9	28.9	32.4	40.7	24.0	16.0	26.9	41.7
% Below Biomass Standard	*54.3*	*51.1*	*62.1*	*66.6*	*48.0*	*40.0*	*57.7*	*58.4*
Between the Standard and Twice the Standard	26.0	24.4	29.7	18.5	36.0	32.0	19.2	25.0
More Than Twice the Standard	19.7	24.4	8.1	14.8	16.0	28.0	23.1	16.7
% Above Biomass Standard	*45.7*	*48.8*	*37.8*	*33.3*	*52.0*	*60.0*	*42.3*	*41.7*

Table 24. Standardized income categories, Zomba-Malosa Forest Reserves.

Standardized Income	Zomba (%)	Sex of HH Head (%)		Villages Surveyed (%)				
		Male	Female	Chilasanje	Mbuliwa	Malemia	Mdumu	Chikanda
Less Than Half the Standard	9.6	8.8	11.1	12.0	0.0	8.0	8.0	20.0
Between Half the Standard and the Standard	22.4	20.0	26.7	16.0	8.0	36.0	32.0	20.0
% Below Biomass Standard	*32.0*	*28.8*	*38.0*	*28.0*	*8.0*	*44.0*	*40.0*	*40.0*
Between the Standard and Twice the Standard	20.8	20.0	22.2	20.0	16.0	28.0	20.0	20.0
More Than Twice the Standard	47.2	51.3	40.0	52.0	76.0	28.0	40.0	40.0
% Above Biomass Standard	*68.0*	*71.3*	*62.0*	*72.0*	*92.0*	*56.0*	*60.0*	*60.0*

Table 25. Standardized income categories, Liwonde National Park.

Standardized Income	Liwonde (%)	Sex of HH Head (%) Male	Sex of HH Head (%) Female	Villages Surveyed (%) Likulungwa	Chatama	Kamwendo	Balakasi
Less Than Half the Standard	22.0	19.4	28.6	20.0	28.0	16.0	24.0
Between Half the Standard and the Standard	25.0	26.4	21.4	36.0	20.0	28.0	16.0
% Below Biomass Standard	*47.0*	*45.8*	*50.0*	*56.0*	*48.0*	*44.0*	*40.0*
Between the Standard and Twice the Standard	25.0	26.4	21.4	16.0	32.0	32.0	20.0
More Than Twice the Standard	28.0	27.8	28.6	28.0	20.0	24.0	40.0
% Above Biomass Standard	*53.0*	*54.2*	*50.0*	*44.0*	*52.0*	*56.0*	*60.0*

Table 26. Standardized income categories, Dzalanyama Forest Reserve.

Standardized Income	Dzalanyama (%)	Sex of Household Head (%) Male	Sex of Household Head (%) Female	Villages Surveyed (%) Mthan-g'ombe	Kampham-banya	Tsumbi	Kanjinga
Less Than Half the Standard	22.0	19.2	31.8	20.0	4.0	44.0	20.0
Between Half the Standard and the Standard	17.0	15.4	22.7	12.0	24.0	24.0	8.0
% Below Biomass Standard	*39.0*	*34.6*	*54.5*	*32.0*	*28.0*	*68.0*	*28.0*
Between the Standard and Twice the Standard	30.0	30.8	27.3	36.0	40.0	16.0	28.0
More Than Twice the Standard	31.0	34.6	18.2	32.0	32.0	16.0	44.0
% Above Biomass Standard	*61.0*	*65.4*	*45.5*	*68.0*	*68.0*	*32.0*	*72.0*

Table 27. Standardized income categories, Vwaza Wildlife Reserve.

Standardized Income	Vwaza (%)	Sex of Household Head (%)		Villages Surveyed (%)			
		Male	Female	Mowa	Kapalala	Kapemba	Thomas Mkandawire
Less Than Half the Standard	8.0	9.3	4.0	12.0	4.0	4.0	12.0
Between Half the Standard and the Standard	19.0	18.7	20.0	28.0	28.0	8.0	12.0
% Below Biomass Standard	*27.0*	*28.0*	*24.0*	*40.0*	*32.0*	*12.0*	*24.0*
Between the Standard and Twice the Standard	25.0	25.3	24.0	36.0	24.0	12.0	28.0
More Than Twice the Standard	48.0	46.7	52.0	24.0	44.0	76.0	48.0
% Above Biomass Standard	*73.0*	*72.0*	*76.0*	*60.0*	*68.0*	*88.0*	*76.0*

These results are consistent with the asset and income data that form the basis of the analysis here. They are decisive in showing the truly impoverished level of the population abutting the protected areas and the precariousness that characterizes household existence under such conditions of scarcity. These conclusions are further supported by the interview data that emphasize the local desire to expand agricultural production as well as the resentment at protected area boundaries.

From the community perspective, the majority of the sampled households consider themselves to be poor and food insecure. As Table 28 indicates, in four of the protected areas over 75 percent of respondents state that they cannot produce enough food to last the year. The exception to this is Vwaza, with slightly over one-half the households responding reporting a seasonal deficit. The results suggest that this problem is gendered. In Mulanje, Liwonde, and Dzalanyama, female-headed households were more likely to be food insecure then male-headed households. In Zomba-Malosa, male household heads are more likely to report shortfalls than are female household heads, and a similar pattern obtains in Vwaza. In both these areas, male household heads are more likely to complain of poor soil fertility and a lack of available fertilizer than are female household heads. In areas where female-headed households are more likely to be food insecure, poor soil fertility, the high cost or lack of availability of fertilizer and/or land shortages were the most commonly reported reasons.

Table 28. Community perceptions of poverty and food insecurity.

Protected Area/ Sex of Household Head	Sufficient Food for Entire Year		Reasons for Problems Obtaining Food (%)				
	Yes (%)	No (%)	Lack or High Input	Land Shortage	Poor Soil Fertility	Production Short Fall	Lack of Employment
Zomba-M.	**21.60**	**78.40**	**56.80**	**36.00**	**36.00**	**13.60**	**31.20**
Male	17.50	82.50	61.25	41.25	47.50	20.00	23.75
Female	28.89	71.11	48.89	26.67	15.56	0.22	44.44
Mulanje	**20.50**	**79.50**	**33.07**	**70.08**	**56.69**	**22.83**	**28.35**
Male	25.55	74.44	27.78	73.33	50.00	24.44	28.89
Female	8.11	91.89	45.95	62.16	72.97	18.92	27.03
Liwonde	**33.00**	**65.00**	**16.00**	**52.00**	**37.00**	**18.00**	**11.00**
Male	42.86	57.14	20.83	55.56	37.50	20.83	0.97
Female	10.71	89.29	0.30	42.86	35.71	10.71	14.29
Dzal.	**20.00**	**79.00**	**72.00**	**46.00**	**68.00**	**15.00**	**26.00**
Male	20.78	79.22	71.79	48.72	64.10	19.23	23.08
Female	18.18	81.82	72.73	36.36	81.82	0.00	36.36
Vwaza	**44.00**	**56.00**	**34.00**	**38.00**	**43.00**	**0.60**	**29.00**
Male	37.33	62.67	41.33	45.33	52.00	0.67	28.00
Female	64.00	36.00	12.00	16.00	16.00	0.40	32.00

Table 28 lends further support to the argument presented above. Locally perceived causes of lower food productivity focus primarily on the lack of land and declining soil fertility. The problem of poor soil quality is further compounded by the lack of availability or the high cost of fertilizers to help improve soil quality. Respondents consistently blame the lack of employment opportunities for their inability to secure enough additional income to purchase fertilizers. The inability to produce sufficient quantities of food in turn contributes to demand on reserve resources as a strategy to overcome food shortage periods. This demand becomes the focus of the following sections.

7.3 Protected Area Resource Utilization Patterns

The survey interviews sought to measure in a detailed fashion the volume of resources utilized by the sample respondents. In the analysis of the resulting data, four general categories of resources were created: wood products for fuelwood and for construction (e.g., poles), thatch for roofing, wild foods (including bushmeat), and medicinal products, all of which are “produced” in the five protected areas under study (See Figure 50.). These resources are employed in a wide range of applications, and the same specific product can have diverse utilizations such as an income-earning output (e.g., fuelwood for sale), as an input into other income-generating activity (e.g., fuelwood for brick-making or for brewing), or for the maintenance of the domestic unit (e.g., fuelwood for cooking).

Figure 50. Utilization model.

native foods and meat, especially during the "hungry season" that characterizes the preharvest planting time as resources drawn from protected areas. It can thus be said that the surrounding communities "harvest" the reserves both to provision the household economy and to create income-earning opportunities.

At the same time, the protected areas are sources for the supply of critical resources to a wider Malawian society. For example, the Dzalanyama National Forest is the principal source of fuelwood for the urban population of Lilongwe, the estate sector near Mulanje depends on that reserve for the wood to cure its tobacco, Liwonde provides a tourism service to outsiders, and so forth. In this sense, it is possible to refer to both a "domestic" economy that contributes to the sustenance of the households surrounding the protected areas as well as to an "export" economy that contributes to the well-being of a wider society.

The survey data provide a more comprehensive description of the domestic economy of local communities who use the resource base. First, all protected area resources were converted into a kilogram basis in order to create an encompassing measure of overall utilization. (The conversion rates from non-standard measures are available in the Data Manual at sites noted in section 4.5) By measuring all resource category in kilograms, it is possible to calculate an estimate of utilization intensity, which then forms the basis of analysis.[54] As was the case with the income estimates, it is necessary to create a comparative standard against which the intensity of utilization can be assessed. As a first step toward creating this baseline measure, wood consumption was standardized. Not only does wood constitute the greatest proportion of resource utilization, but there is also a national per capita usage estimate for Malawi: 388 kilograms of wood annually. To account for the non-wood resources, total weight in kilograms was calculated from non-standard measures reported by households, then the total sample mean was derived. The per capita mean for the non-wood resource utilization was 263 kilograms per year. This figure was added to the combined wood standard to provide an overall per capita biomass utilization standard of 650 kilograms per year. Once this standard was calculated, it was disaggregated into four levels of use based on the household's intensity of utilization. Thus, if the household's annual per capita biomass utilization was greater than 1300 kgs (twice the national standard), they were grouped into one category. If utilization was greater than or equal to the national standard but below twice the standard, they fell into a separate category. If it fell below the standard, households were grouped based on whether it was between one half of the standard (325 kilograms) and the standard or, as a last category, below 325 kilograms. With these four categories, it was possible to analyze each protected area separately and further disaggregate the data by sex of household head to see if resource utilization has a gendered component to it. The results are also presented at the village level to see if there were distinct utilization patterns within specific communities. These findings are discussed in detail below according to protected area.

[54] It is recognized that a kilogram of wood is not the same as a kilogram of thatch or of masuku fruit; it is likely that the proportions of different products that make up the "utilization basket" are generally similar across all the forested reserves.

In terms of intensity of utilization, more than 92 percent of the households report a reliance on protected area resources, with wood products constituting between 70 and 90 percent of the total volume by weight. Table 29 demonstrates the more intensive use of wood both in terms of percentage of user households and the volume extracted. Clearly fuelwood for subsistence (cooking and heating) is the most critical resource for households around all of the protected areas. Additionally, fuelwood provides an important source of income through supplying and vending, for brewing beer and for baking bricks, and for making utilitarian crafts. Construction and carpentry woods are also highly demanded. Among the five protected areas, Vwaza is the largest per capita supplier not only of wood products but also of non-wood resources, including food. In Liwonde, the table shows a high average extraction of medicinal and ceremonial plants; however this reflects a single specialist (a healer) rather than a reserve-wide pattern. Between the male and female-headed households, there are also patterns of specialization. Women appear to be designated gatherers of fuelwood and, in Vwaza and Dzalanyama, even construction woods (although the sample number is small). The female headed households (which have more female members) also appear to be specialized food gatherers, except in Vwaza. With regard to medicinal and ceremonial items, the male headed households (most likely, the male members) are the principal users.

Table 29 provides solid insights into the intensity of use of the reserve resources by the local communities abutting the protected areas. Average utilization rates of between one and fifteen tons of biomass per capita are exceedingly high compared to the national standard; however average numbers often conceal the distributional patterns of resource use, and the standard deviations for all these estimates are high. In Tables 30-34, each household is located into the four categories created around the national standard of biomass utilization in order to provide a measure of comparison. In the case of Mulanje, a national forest, nearly two-thirds of the households are situated in the categories above the standard, and nearly 30 percent of the sample utilizes twice the national measure (Table 30). For Zomba-Malosa, the utilization rates vary around the national standard, but there is significant inter-village variation. In the two communities with most household in the higher categories, public employment in the reserve is also high. Such employment (for example, as forest guard) favors easy access to the resource base. About 75 percent of the households in Mbuliwa and in Chilsanje (Table 31) are employed within the boundaries of the protected area. In comparison, Chikanda is a peri-urban community with less access to the reserve.

For Liwonde, a tourist park, the households in most communities are located in the lower categories, with the exception of Likulungwa, which due to a higher level of wood extraction has more households in the higher categories of utilization (Table 32). In Dzalanyama, again a national forest, about two-thirds of the households are located in the higher utilization categories, with little differences between villages or between male and female households (Table 33). Finally, in Vwaza, the most intensely utilized reserve, no households are found in the lower categories, and nearly the entire sample is located in the highest (Table 34). One of the reasons that explain these intensive use rates lies in the high incidence of brewing among the women in these communities and the use of poles for building tobacco sheds; however, there are clearly other resource-dependent activities that contribute to the high demand for these reserve resources.

Table 29. Intensity of biomass utilization per capita, by protected area.

Protected Area/ Sex of Head of HH	Contributing Components to Utilization Calculation in Kilograms							Total
	Wood Products				Other Products			
	Construction	Poles	Fuelwood	Total Wood	Food	Grass/ Thatch	Medicine	Total Volume
Mulanje (127)	*1313* *N=25*	*220* *N=3*	*722* *N=105*	*1041* *N=105*	*181* *N=97*	*144* *N=82*	*4* *N=20*	*1250* *N=111*
Male (90)	1395 N=21	220 N=3	569 N=74	973 N=74	129 N=70	130 N=57	3 N=13	1120 N=79
Female (37)	885 N=4	0	1090 N=31	1204 N=31	316 N=27	176 N=25	5 N=7	1571 N=32
Zomba-Malosa (125)	*1268* *N=46*	*0*	*1687* *N=107*	*2132* *N=112*	*57* *N=66*	*69* *N=26*	*13* *N=9*	*2164* *N=113*
Male (80)	1491 N=38	0	1821 N=70	2455 N=75	29 N=48	45 N=20	9 N=5	2454 N=76
Female (45)	205 N=8	0	1434 N=37	1479 N=37	130 N=18	149 N=6	17 N=4	1568 N=37
Liwonde (100)	*1141* *N=20*	*52* *N=20*	*580* *N=64*	*884* *N=69*	*103* *N=29*	*168* *N=23*	*399* *N=10*	*971* *N=74*
Male (72)	1200 N=19	56 N=18	572 N=51	946 N=56	93 N=26	179 N=19	443 N=9	1046 N=60
Female (28)	27 N=1	17 N=2	614 N=13	619 N=13	184 N=3	114 N=4	0	646 N=14
Dzalanyama (100)	*1691* *N=36*	*69* *N=29*	*661* *N=93*	*1296* *N=96*	*148* *N=96*	*315* *N=66*	*24* *N=52*	*1622* *N=99*
Male (78)	1475 N=30	68 N=27	656 N=73	1237 N=76	136 N=77	275 N=52	26 N=41	1537 N=78
Female (25)	2772 N=6	80 N=2	681 N=20	1520 N=20	193 N=19	463 N=14	16 N=11	1940 N=21
Vwaza (99)	*7549* *N=83*	*225* *N=78*	*4363* *N=100*	*14529* *N=100*	*240* *N=100*	*364* *N=91*	*63* *N=98*	*11501* *N=100*
Male (75)	5604 N=66	239 N=66	2743 N=75	7884 N=75	255 N=75	364 N=68	68 N=74	8537 N=75
Female (24)	15098 N=17	152 N=12	9429 N=24	20194 N=24	193 N=24	356 N=23	49 N=23	20767 N=24

Table 30. Biomass utilization classifications, Mulanje.

Standardized Biomass Utilization	Mulanje (%)	Sex of Household Head (%)		Villages Surveyed (%)				
		Male	Female	Nessa	Lupiya	Kambenje	Mlelemba	Kadewere
Less Than Half the Standard	14.4	18.99	3.13	26.3	12.5	21.7	13.6	0.0
Between Half the Standard and the Standard	19.8	16.45	28.13	15.8	16.7	17.4	27.3	21.7
% *Below* Biomass Standard	34.2	35.44	31.26	42.2	29.2	39.1	40.9	21.7
Between the Standard and Twice the Standard	36.0	37.97	31.25	36.8	50.0	30.4	31.8	30.4
More Than Twice the Standard	29.7	26.58	37.5	21.1	20.8	30.4	27.3	47.8
% *Above* Biomass Standard	65.7	64.55	68.75	57.9	70.8	60.8	59.1	78.2

Table 31. Biomass utilization classifications, Zomba-Malasa.

Standardized Biomass Utilization	Zomba (%)	Sex of Household Head (%)		Villages Surveyed (%)				
		Male	Female	Chilasanje	Mbuliwa	Malemia	Mdumu	Chikanda
Less Than Half the Standard	26.5	28.95	21.62	12.0	13.6	40.9	20.0	45.8
Between Half the Standard and the Standard	24.8	26.31	21.62	24.0	22.7	27.3	30.0	20.8
% *Below* Biomass Standard	51.3	55.26	43.24	36.0	36.3	68.2	50.0	66.6
Between the Standard and Twice the Standard	18.6	15.79	24.32	24.0	22.7	9.1	20.0	16.7
More Than Twice the Standard	30.1	28.95	32.43	40.0	40.9	22.7	30.0	16.7
% *Above* Biomass Standard	48.7	44.74	56.75	64.0	63.6	31.8	50.0	33.4

Table 32. Biomass utilization categories, Liwonde.

Standardized Biomass Utilizaton	Liwonde (%)	Sex of Household Head (%)		Villages Surveyed (%)			
		Male	Female	Likulungwa	Chatama	Kamwendo	Balakasi
Less Than Half the Standard	32.4	33.33	28.57	15.0	39.1	50.0	31.6
Between Half the Standard and the Standard	24.3	25.0	21.43	25.0	21.7	16.7	31.6
% *Below* Biomass Standard	56.7	58.33	50.0	40.0	60.8	66.7	63.2
Between the Standard and Twice the Standard	23.0	18.33	42.86	25.0	26.1	16.7	21.1
More Than Twice the Standard	20.3	23.33	7.14	35.0	13.0	16.7	15.8
% *Above* Biomass Standard	43.3	41.66	50.0	60.0	39.1	33.4	36.9

Table 33. Biomass utilization categories, Dzalanyama.

Standardized Biomass Utilization	Dzal. (%)	Sex of Household Head (%)		Villages Surveyed (%)			
		Male	Female	Mthang'ombe	Kampham-banya	Tsumbi	Kanjinga
Less Than Half the Standard	16.2	17.95	9.52	24.0	16.0	20.8	4.0
Between Half the Standard and the Standard	18.2	19.23	14.29	12.0	16.0	29.2	16.0
% *Below* Biomass Standard	34.4	37.18	23.81	36.0	32.0	50.0	20.0
Between the Standard and Twice the Standard	28.3	24.36	42.86	20.0	20.0	41.7	32.0
More Than Twice the Standard	37.4	38.46	33.33	44.0	48.0	8.3	48.0
% *Above* Biomass Standard	65.7	62.82	76.19	64.0	68.0	50.0	80.0

Table 34. Biomass utilization categories, Vwaza.

Standardized Biomass Utilization	Vwaza (%)	Sex of Household Head (%)		Villages Surveyed (%)			
		Male	Female	Mowa	Kapalala	Kapemba	Thomas Mkandawire
Less Than Half the Standard	0	0	0	0	0	0	0
Between Half the Standard and the Standard	0	0	0	0	0	0	0
% *Below* Biomass Standard	0	0	0	0	0	0	0
Between the Standard and Twice the Standard	11.0	10.7	12.0	4.0	4.0	8.0	28.0
More Than Twice the Standard	89.0	89.3	88.0	96.0	96.0	92.0	72.0
% *Above* Biomass Standard	100.0	100.0	100.0	100.0	100.0	100.0	100.0

To help explain the high volume of extraction in Vwaza, one hypothesis that could be tested in the future is the relationship between utilization and the overall availability and diversity of resources. The PLUS resource assessment indicated that Vwaza had the highest diversity and biomass in woodland areas of the three sites.

The survey results strongly support the conclusion that the communities around the protected areas are heavy users of this resource base. While there are major difference between Liwonde at the low end and Vwaza at the high end, the vast majority of households are above the national standard. The reasons that explain protected area variation and inter-village variation are to be found in the ease of access to the reserve and to the relationship between utilization and livelihood system. This latter factor is discussed in the following section.

7.4 The Economic Importance of Protected Areas Resources

The final question to be addressed in this chapter is the importance of the protected area resource base to the welfare of surrounding communities and to the national economy. In the first instance, the impact of proximity to the protected areas on the domestic economy is measured in terms of the employment and income that reserve resources bring to local households. To demonstrate the importance of the public lands economy, the total value of all income-earning activities derived from the protected areas was calculated as a share of total income for each household. In a local economy in which large segments of the local population are barely capable of sustaining their livelihoods, any regular cash inflow into the household is critical. As stated previously, all economic activities that involve reserve resources—either as an input or an output—is included in this income category. Also of significant importance is direct public employment on the reserve as a ranger, guard, laborer, or any other official capacity. What is not included in this category is the quantity of resources that are extracted for domestic consumption (e.g., household fuelwood) and are not "monetized" in any fashion. Thus, while virtually every household is dependent upon and utilizes the protected area resources, not all families directly derive income. As seen in Table 35, the over half the households derive some income from the use of the protected areas, and that level of income accounts for about one-quarter of total household income. If "indirect" agricultural and livestock income (that is, products not sold but consumed at home) is removed, the protected area contribution becomes much higher.

Table 35. Share of protected area income in local household economy.

Protected Area	Overall Utilization (% of HHs)	Direct Economic Benefit (% of HHs)	Per Capita Income Estimates from Protected Areas (MK)	Share of Protected Area Income in Total (%)
Zomba-Malosa	90.4	41.6	738	27.6
Mulanje	87.4	54.3	495	30.5
Liwonde	74.0	40.0	968	30.7
Dzalanyama	99.0	67.0	299	20.6
Vwaza	100.0	49.0	231	9.3
Total	90.0	50.2	510	23.1

The critical insight from these results is that for these households on the margin, the income derived from the protected areas might represent the survival difference. It is important to observe further that the protected area income contributes a relatively higher level to the poorest, most land-scarce communities around Mulanje and Liwonde. There is further evidence of the importance of the protected areas to the local household economy. In Table 36, the four overall biomass utilization categories are compared to average per capita income levels and per capita land (as a proxy measure of assets). In all of protected areas, the higher intensity of biomass utilization is associated with higher income levels and, less robustly, with land per capita. This table supports the conclusion that the protected areas provide critical support to local household economies, even for those households not directly deriving income from reserve resources.

It is clear that the populations surrounding the protected areas benefit from this proximity. Even though access is, in principle, controlled and fees are established, the quantitative and qualitative information suggests that most people use the reserves at will, despite the transaction costs of unauthorized entry, occasional harassment by guards, and, in some cases, the exacting of fees. It is ironic to some extent that resentment over current boundaries is so prevalent. In effect local households do use the resource base extensively, but still wish to occupy the lands for farming. While farming does provide the higher share of well being, it is unlikely that the protected areas could support open-access farming and still provide non-farming resources at current levels in sustainable manner.

Table 36. Income and land by biomass utilization category.

Protected Area	Biomass Category	Average Income per Capita (MK)	Land per Capita (ha)
Zomba-Malosa	1	4221	0.27
	2	3683	0.40
	3	2279	0.18
	4	2422	0.22
Mulanje	1	2158	0.19
	2	1563	0.15
	3	1088	0.15
	4	997	0.16
Liwonde	1	3509	0.23
	2	2095	0.24
	3	1517	0.18
	4	2243	0.20
Dzalanyama	1	4225	0.45
	2	2422	0.49
	3	1389	0.21
	4	1574	0.34
Vwaza	1	3648	0.32
	2	5545	0.41
	3	N/A.	N/A.
	4	N/A.	N/A.
Total	1	3598	0.31
	2	2591	0.31
	3	1631	0.18
	4	1949	0.22

There is a wider issue related to the "export" economy of the protected areas. Currently, the reserves provide more distant populations important resources not available locally. For example, the forest reserves supply fuelwood to urban areas and to the tobacco sector (fuelwood for curing leaves); charcoal for a variety of heating and cooking uses; bricks for construction; brooms, brushes, and mats fashioned from local grass species, and, in a limited fashion, bushmeat (often poached), fish, and wild fruits and medicinal products.

Some of this export trade is captured in the communities studied here, since each tends to have one or more "export" specialists who gather, produce, and sell these products (e.g., healers, hunters, fuelwood vendors, artisans, etc.). A significant amount of this activity is, however, organized by outsiders who capture the majority of the benefits of extraction. Similarly, in national parks, like Liwonde, the export product is tourism, and people sell tourism services, although the benefits do not, once again, tend to remain within the surrounding communities. Thus, while it is difficult to quantify the extent of this export component, it is certainly as large or larger than the domestic component in some of the more accessible reserves (i.e., more so in Liwonde and Zomba-Malosa and less so in Vwaza). In a country like Malawi, where no feasible alternative to fuelwood cooking has yet been introduced and where foreign tourism appears to have great potential for national economic development, the protected areas assume an importance that far exceeds the well-being of the local residents, as critical as their needs might be.

7.5 Resource Assessment

Mensuration specialists and a botanist FRIM conducted a use-oriented ecological study of the resource utilization areas identified during the participatory mapping phase of PLUS. Participatory mapping was conducted in each of the 4 or 5 intensively studied villages around each of the five Level II protected areas. Villagers helped the socio-economic researchers map present land use and vegetation onto clear acetate over 1994 aerial photos (1:25,000) supplied by ELUS. The resource assessment team then visited these resource utilization areas, and placed a total of eight plots per village.

Within the 10 by 10 meter plots, all trees were identified and measured for height and basal diameter to help estimate stem volume as an assessment of woody biomass. For herbaceous species, 40 by 40 cm quadrats were placed in twelve locations in each plot; within each quadrat, species were identified and percent cover as well as density were estimated. Finally, an assessment of actual and potential use was noted for each species with the help of one or two male and female villagers who assisted the team.

The high basal area and corresponding stem volume noted for Zomba and Mulanje is indicative of the facilitated access to Forestry Department pine and eucalyptus plantations provided by roads (Table 37). These same attributes are also indicative of lower tree species diversity. Diversity in Liwonde is low because the native vegetation is predominately Mopane Woodland, which, unlike Miombo Woodland, is made up of an association of only two or three species in most cases. The low stem volume and diversity in Dzalanyama is related to soils and physiography as well as high levels of use (particularly in supply of the Lilongwe urban market). Vwaza, on the other hand, has exceptionally higher diversity due to a much greater availability of the resources (in what is entirely natural vegetation) and much lower population pressure.

Table 37. Summary results from ecological analysis of the resource assessment.

Protected Area for Village Summaries	Canopy Cover (%)	Basal Area (m^2)	Stem Vol. (m^3)	Tree Diversity
Mulanje	79	0.129	1.759	1.381
Zomba-Malosa	50	0.099	1.851	1.242
Liwonde	41	0.060	0.279	1.212
Dzalanyama	41	0.052	0.447	1.302
Vwaza	45	0.044	0.187	2.328

An evaluation of both resource assessment data in combination with socio-economic summaries, combined across villages for each of the five protected areas, suggests some interesting patterns. Utilization is lower where access is limited (i.e. high protection in Liwonde or steep slopes in Mulanje and Zomba-Malosa), but it is also lower where extraction and encroachment has been high in the past. For example, over the years, the boundary in Mulanje has officially contracted on virtually all sides as pressure for land forced contraction in the reserve boundary. The current reserve boundaries are predominantly at the base of steep slopes, the resources on which having been heavily utilized in the past. By contrast, population pressure in Vwaza is low. PLUS rapid appraisal information revealed that estate land pressure is very high, but the man-power to farm the estates has not been sufficient, leaving many newly created estates idle. Even among those that have been successfully cleared, there is strong evidence of tree regeneration. The woody species resource base is very high, relatively easy to access, and remains highly diverse.

8. IMPACT ON THE RESOURCE

The analysis of the nature of protected area land resources and the potential human pressures provides a foundation for understanding associated human impacts. The last chapter analyzed the basis for those impacts through the interrelationship between communities adjacent to the land and resources protected within parks and reserves. This leaves open the question of whether change has occurred, and whether that change can be characterized by expansion of cultivation or biomass utilization.

Impact on protected area resources is difficult to ascertain without information related to several different points in time to allow comparison and trend analysis. Even more difficult is the task of explaining why the impact occurs. PLUS analysts addressed the issue of estimating change by producing land cover maps for 1984 and 1994, and then quantifying the differences between them. The resulting products have a defined scope. Beyond the quantified results, further inferences can be drawn, limited only by the field knowledge of the site under evaluation possessed by the interpreter.

The maps and digital data provide land managers with valuable tools for assessing changes they have observed over the decade in question. These products can also be used as benchmarks for comparison to any future changes. In cases where the change detected is associated with anthropogenic land cover classes (i.e. “predominantly agriculture), impact can be more directly linked to human activity. Changes to and from classes which are not distinctly man-made (i.e. natural forest or herbaceous classes) can only be explained by the interpretations of people directly knowledgeable about the areas during the time frame under analysis. The PLUS land cover and change detection maps therefore provide information well beyond the scope of the study. This information is extremely valuable for the management of these protected areas.

8.1 Land Cover Mapping

8.1.1 Image Data Acquisition and Description

The Government of Malawi (GOM), through MEMP, requested that where ever possible PLUS integrate data, analysis and methods with the objectives of the prototype EIS. PLUS therefore purchased 1994 and 1984 Landsat Thematic Mapper data for the entire country, from which the five Level 2 sites were extracted (see Appendix C for a list of specific scenes acquired). In selecting the images, special care was taken to avoid imagery with excessive cloud cover and scenes of poor data quality. Furthermore, it was important to identify two data sets (1984 and 1994) collected during the same vegetation phenological period that also possessed the same spectral and spatial resolution.

The purchased data were all collected at the end of the dry season to enhance the potential to discriminate between vegetation communities by exploiting the maximum phenological contrast such as that between evergreen forest types and drought deciduous classes (including Miombo Woodland, the most common forest cover in Malawi). The end of the dry season is also the most likely period to have cloud free images. data. The alternative available images that met the above requirements were very limited. In some cases, minimal cloud cover was unavoidable. PLUS considered the possibility of enhancing the analysis by evaluating both wet and dry season images, but cloud cover problems and project constraints did not permit this.

Eleven Landsat 5 TM scenes were necessary for complete coverage of Malawi. Each full TM scene covers an area approximately 185 km x 185 km. The 1994 digital data were purchased from EOSAT and the South African Ground Receiving Station. These data were acquired during the dry season between August and November of 1994 with the majority collected in October. The historical data from the dry season of 1984 were purchased from EROS Data Center (EDC). Eleven Landsat 5 TM Scenes were selected to cover the entire country of Malawi with as little cloud cover as possible. These historical data were collected between August and December

The choice of Thematic Mapper data was based on its high spatial resolution and the availability of scenes for all of Malawi during the time frames requested. The TM sensor is an digital imaging system on the Landsat 5 Satellite that was launched in 1984 and continues to collect data today. The spectral range of the data acquired by this system includes six spectral bands in the visible and near-infrared portions of the electromagnetic spectrum, and a thermal infrared band. All but the thermal band (which was not used in this study) have a spatial resolution of 30 meters. This means that for each 30 meter x 30 meter square area on the ground, the sensor measures radiance in each spectral band.

The spectral and spatial resolution of TM data does not allow for mapping individual species mapping but rather vegetation communities. In some cases it is difficult to discriminate between more general vegetation communities such as grassland and other forms of herbaceous vegetation or agriculture

8.1.2 Earlier Land Cover Mapping Using Satellite Images in Malawi

In a previous study by the Forestry Department and the Swedish Space Corporation (Forestry/Satellitbild), remote sensing data were purchased and used to create vegetation and land use maps.[55] Unfortunately, the raw digital data purchased and used in that study were not available for use in this project. Only the final products of national level, digital vegetation maps were available to PLUS. The study used Multispectral Scanner (MSS) data from 1972/1973 and Landsat Thematic Mapper (TM) data from 1990/1991 to produce false color composites (TM 453 in red, green and blue). These composites were then printed in analog form and evaluated manually using classic photo interpretation methods.

Had these data been available in their original raw digital form, it may have been possible to analyze them with the computerized classification methods used by PLUS. However, PLUS was able to use the digital, national, land cover maps produced in the Forestry/Satellite build for change detection and as an input layer in the modified SLEMSA erosion hazard model (see Chapter 9).

[55] Satellitbild, 1993. Forest Resources Mapping and Biomass Assessment for Malawi. Satellitbild, Lilongwe.

8.1.3 Image Processing

8.1.3.1 Atmospheric and Radiometric Correction

The processes of atmospheric and radiometric correction diminish the differences between image acquisition dates due to sensor and atmospheric variation. This allows for improved change detection analysis by concentrating on differences in land cover classes, rather than changes in the atmosphere or the sensor itself.

The most accurate methods for atmospheric and radiometric correction of satellite data require complex models and in-situ data at the time the data are acquired. Historical data, such as the 1984 Landsat Satellite Thematic Mapper coverage of Malawi obtained for PLUS, require alternative methods for atmospheric and radiometric correction as no in-situ information is available.

For this reason an image-based atmospheric and radiometric correction method known as COST was selected for the PLUS image processing.[56] The COST method uses the cosine of the solar zenith angle, sun-earth distance, and approximations of atmospheric conditions at the time of data acquisition to calibrate the data set. In addition, it is easy to implement, cost-effective, and relatively accurate.

8.1.3.2 Masking

Where clouds and shadows exist, little or no information can be extracted to determine the land cover class. Therefore, it was necessary to create digital “masks” for these areas to eliminate them from further processing so that they do not become confused with land cover. By virtue of the mask, wherever clouds or cloud shadows existed in either the 1984 or 1994 images, the clouded areas were not used in the change analysis. Likewise, digital masks were created for the large water bodies for the areas where the water body was largest between the images, and then applied to images from both years prior to change analysis. In this manner the classification of land cover types was improved and changes caused by changes in cloud cover, their shadows and varying water levels were minimized.

Differences in lighting conditions from the 1984 to 1994 images were simulated using a shaded relief image derived from the DEM and information regarding the sun azimuth and sun elevation at the time the data were acquired (Figure 51). Differences in illumination from one year to the next will be most prevalent in rugged terrain such as near outcrops in Mulanje and Zomba-Malosa. Changes due differences in sun angle conditions were evaluated as neutral in the change detection evaluation of the Impact model.

[56] Chavez, P. 1996. Image-based atmospheric corrections – revisited and improved. Photogrammetric Engineering & Remote Sensing 62 (9) 1025-1036.

Figure 51. Comparison of sun elevation and azimuth for satellite image acquisition dates.

8.1.3.3 Image Georeferencing

The purpose of georeferencing images is to relate them to known, specific, geographic coordinates. This enables the analyst (and the image processing software) to know the geographic coordinates of any point in the image relative to its location on the ground. It also permits cross-referencing between multiple images of the same location as well as associated maps.

The process of georeferencing has three general steps:

1) selecting appropriate ground control points (GCP);

2) developing a polynomial equation using these GCPs that will warp or stretch the image to a defined projection[57], and;

3) applying this polynomial equation and resampling to the uncorrected image bands to produce a mapped rectified image.

In PLUS analysis, after appropriate ground control points were selected, each image was registered to a Universal Transverse Mercator (UTM) projection through an affine polynomial transformation. Information regarding the collection of ground control points and the accuracy of georeferencing the Landsat Thematic Mapper scenes and subscenes is listed in Appendix D. Following the transformation a resampling was performed using a nearest neighbor algorithm.

The radiometric and atmospheric corrected TM bands 1-5 and 7 from 1984 data were georeferenced to the 1:50,000 Survey Sheets for each area. Later the final land cover image was georeferenced and added to the GIS for use in the modeling activities. The 1994 images were subsequently georeferenced to the 1984 georeferenced image (for error report, see Appendix D). Once again TM bands 1-5 and 7 and the final land cover image for 1994 were georeferenced and added to the GIS for display and modeling purposes.

8.1.3.4 Vegetation Index

Several vegetation indices including the Normalized Difference Vegetation Index (NDVI), Soil Adjusted Vegetation Index (SAVI), and Modified Soil Adjusted Vegetation Index (MSAVI) were examined for use in the unsupervised classification. Vegetation indices have been reported to be significantly correlated with standing green and brown biomass. These indices are used to detect differences or changes in vegetation communities and in vegetation density and extent. Since the data were acquired during the dry season it was thought that a vegetation index that is relatively insensitive to soils influences such as SAVI or MSAVI would be helpful in distinguishing between land cover classes, particularly in the dry season when more soil might be visible. MSAVI was

[57] The warping of the image is the process of geometrically aligning the image data to a map.

determined to be most appropriate and was included as an additional band in the image classification process (for an example, see the left side of Figure 52).[58]

Figure 52. Derived bands (MSAVI and Greenness) used in the unsupervised classification using Thematic Mapper satellite images.

8.1.3.5 Tasselcap Transformation

The Kauth-Thomas tasselcap transformation was also used to better discriminate among land cover classes in the unsupervised classification. Using values specific to Landsat 5 TM, this transformation results in three output bands: greenness, wetness, and brightness. For the PLUS study only the resultant greenness band was used to capture differences in biomass (Figure 52).[59]

8.1.3.6 Unsupervised Classification

Two images for each area from 1984 and 1994 dry seasons were used in the unsupervised classification. An unsupervised classification for each image was performed using 8 input bands; six visible and near-infrared bands (TM bands 1-5, 7), an MSAVI band, and a Tasselcap transformation greenness band. This unsupervised classification is one in which the computer identifies groups of pixels with similar spectral signatures (a pixel is the smallest unit of an image) based on differences in the spectral reflectance in each TM band, the vegetation index and the tasselcap greenness band.

PLUS applied an Iterative Self-Organizing Data Analysis (ISODATA) method for the unsupervised classification.[60] After the computer defined between 26 and 32 classes per study area, the analyst displayed the classes for detailed inspection and naming of land cover classes. If the results were favorable, the analyst then edited and merged classes to arrive at 8-10 final classes. If the first classification results inadequately separated the land cover classes, the data were reclassified iteratively until satisfactory results were obtained. For example, improvements were made when predominately vegetated areas were classified separately from non-vegetated areas (outcrop, soil etc.). Based on field observations, available literature, and communications with the Forestry Department upper and/or lower elevation limits were used to refine some classification results by employing the DEM in conjunction with the land cover image. After the final classes were edited and merged, a smoothing (majority) filter was run on all land cover maps. The purpose of this step was to obtain a more uniform land cover map and to eliminate spurious pixels or small groups of less than six pixels, which in TM data represents about 5400 m^2. This is done by reassigning the single pixel or small group of pixels to the dominant surrounding land cover class.

[58] Qi J, Chehbouni A, Huete A, Kerr Y, and Sorooshian S., 1994. A modified soil adjusted vegetation index. Remote Sensing of Environment, 48(2) 119-126

[59] Crist E.P. and Kauth RJ. (1986) The tasseled cap de-mystified. Photogrammetric Engineering & Remote Sensing, 52(1)81-86.

[60] Tou, J. and R. Gonzalez, 1974. Pattern Recognition Principles. Addison-Wesley Publishing Co.

8.1.4 Land Cover Mapping Results

The development of land-cover naming scheme for the classified images involved comparing the digital results with 1995 aerial photos and PLUS participatory maps and field verification. A total aerial photo coverage from 1994 (provided by ELUS) exists for all the sites studied. Field visits were made to the five study areas to identify land cover classes using preliminary classified images and false color composite images. The false color composite images combine TM bands 4,3,2 and represented in red, green, and blue respectively (see the image on the bottom, right-hand portion of Figures 54-58). An extensive and iterative enhancement and revision of the land cover classes was carried out over several months. In the final naming of the land cover classes analysts received advice from the Forestry Department, FRIM, and DNPW. The description of the final land cover classes for all five areas is given in Table 38.

Table 38. Vegetation and non-vegetation classes.

Vegetation Classes
Moist Hilly Woodland Generally located at higher elevations where there is more precipitation. The vegetation is a mixed Miombo woodland dominated by *Brachystigia* but also including open broad-leaved woodlands. Grasses are generally low and sparse.
Mtwatwa Thicket - Dense evergreen trees containing little herbaceous vegetation.
Thicket - Dense low evergreen or deciduous thicket with highly diverse vegetation.
Miombo Woodland - Consists of a diverse tree community with *Brachystegia* species usually dominant but *Julbernardia* and *Uapaca* species may be common. Miombo Woodland has an understory tree layer, dominated by several species of *Combretum* and *Terminalia*.
Open Miombo Woodland - Less dense stands of Miombo woodland than that found in the Miombo Woodland class. A moderate degradation of a Miombo Woodland class may lead to the class changing to a more open woodland.
Mopane Woodland - Dominated by *Colophospermum mopane* develops on clay plains with very impermeable soils.
Broadleaf Forest - Evergreen and deciduous broad-leaved forests.
Evergreen Forest - Montane evergreen forest with representatives of the genera: *Olea, Pittosporum, Podocarpus, Rapanea,* and *Xymalos*. In Mulanje and limited areas in Zomba this includes *Widdringtonia whytei* or Mulanje cedar.
Mixed Forest - Deciduous forest and Miombo species.
Riverine Forest - Tropical forest dominated by trees that parallel stream and river channels in a wetland environment.
Marsh Vegetation - Vegetation dominated by grassland and papyrus marsh (*Cyperus spp.*) with patches of bull rush (*Typha spp.*) and reeds (*Phragmites spp.*). Limited to areas of permanent or seasonal waterlogging.
Grassland - Montane tussock grassland with *Cyperus spp.* locally abundant predominates. Grassland class can also include varied community of low shrubs and herbs.
Grassland/ Predominately Agriculture - Complex class where areas of grassland predominately near the Shire River; could not be spectrally separated from predominately agriculture class.
Grassland/ Herbaceous Vegetation - Complex class where areas dominated by grasses; could not be spectrally separated from areas with diverse herbaceous vegetation. The grassland may or may not be natural, could be disturbed areas.
Herbaceous Vegetation/ Soil - Complex class with sparsely vegetated areas with patches of bare soil. Where vegetation occurs herbaceous vegetation predominates. Areas that may have been recently cleared for tree planting were mapped in this class.
Dambo/ Waterlogged area - Characterized by tall perennial grasses, often in waterlogged areas, such as those along natural drainage patterns in flat and undulating areas. This is a complex class in that it includes Dambo vegetation and seasonally waterlogged areas that may not necessarily be Dambo.
Eucalyptus Plantation - Forestry Department fuelwood and pole plantation dominated by numerous Eucalyptus species. *Eucalyptus* plantations are usually coppiced every 6-10.
Pine Plantation - Forestry Department timber plantations dominated by a number of *Pinus* species.
Predominately Agriculture - Areas with distinct agricultural pattern suggesting cultivation at present or in the recent past.
Tea Estate - Dominant land cover is cultivated tea plants. Often also large field structures within large estates.
Non Vegetation Classes
Shadow - Areas dominated by shadow (insufficient information for classification into specific class).
Outcrop - Refers to rock outcrops and scarps with little or no soil.
Soil - Areas dominated by soil with little of no vegetation.
Water - Lakes, reservoirs, or wide rivers.
Unclassified - Areas masked due to clouds, cloud shadows, or large water bodies.

8.2 Land Cover Change

8.2.1 Impact Model Design

The land cover maps were compared by digitally superimposing the 1984 map and the map 1994 (Figure 53). The nature and magnitude of change was calculated for each cover class in order to generate a change matrix. The matrix provided detailed results by class; each was individually reviewed for impact so that a change evaluation could be performed.

Change can be evaluated in a variety of ways depending on interpretation objectives, and the specific vegetation classes encountered on each protected area. Based on Lands Steering Committee recommendations, PLUS focused on increases or decreases in natural vegetation cover, particularly where agricultural expansion (in the form of encroachment) could be identified. Generally, natural vegetation classes of higher estimated biomass were rated as having higher positive value. Loss of natural habitat was evaluated as negative, even if associated change was due to expansion of exotic species plantation of higher biomass. As a supplemental theme, other plantation changes in forest reserves were considered separately to better compare with other model results such as potential population pressure. Neutral changes were those which occurred within classes or between similar vegetation types (i.e. from one type of woodland to another). Evaluation criteria were developed for each Level 2 site so that the total area of positive, negative and neutral change could be quantified and mapped.

8.2.2 Impact Model Results

Graphic representations of land cover change evaluations are available in Figures 54-58 for each of the five Level 2 sites. The tabular results (Table 39) show that Zomba-Malosa, Vwaza and Liwonde all experienced negative change in approximately 10% of their respective total land area. In the case of Zomba-Malosa, a portion of this is due to forest fires in 1994. For Vwaza, the results correspond to the very high biomass utilization figures noted in Chapter 7 as well as some encroachment on the eastern boundary. Encroachment also explains a portion of the change in Liwonde's northeastern boundary, just south of the extension.

Summary results of land area change by vegetation class are detailed in Table 40, which follows the five maps. More detail on the change evaluation criteria, their application, and interpretations the resulting maps follows that table.

Table 39. Summary of negative, positive and neutral land cover change.

	Negative	Positive	Neutral	Sum
	--(percentage of total land area)--			
Zomba-Malosa Forest Reserves	12	8	79	100%
Vwaza Wildlife Reserve	10	6	84	100%
Liwonde National Park	9	2	89	100%
Mulanje Forest Reserve	5	3	91	100%
Dzalanyama Forest Reserve	3	5	91	100%

Figure 53. Impact model.

Figure 54. Land cover mapping and change evaluation for Mulanje.

Figure 55. Land cover mapping and change evaluation for Zomba-Malosa.

Figure 56. Land cover mapping and change evaluation for Liwonde.

Figure 57. Land cover mapping and change evaluation for Dzalanyama.

Figure 58. Land cover mapping and change evaluation for Vwaza.

Table 40. Percent land cover change by class for each Level 2 site (land area in ha).

Mulanje	Miombo	Tea Estate	Evergreen	Grass	Pine	Eucalyptus	Pred. Ag.
1984	10,654	22	17,760	15,780	547	0	1,453
1994	11,104	37	16,675	12,125	1,374	1,627	2,698
	+4%	*+68%*	*-6%*	*-23%*	*+151%*	*(new)*	*+85%*
Zomba	Miombo		Evergreen	Grass	Pine		
1984	8218		4055	2591	3227		
1994	7680		3909	3026	3602		
	-7%		*-4%*	*+17%*	*+12%*		
Dzal	Miombo	Open Miombo	Broadleaf	Grass/Hb	Pine	Eucalyptus	
1984	45,862	1,932	266	9,177	372	130	
1994	47,441	3,521	284	3,003	1,488	2,003	
	+3%	*+82%*	*+7%*	*-67%*	*+300%*	*+1,446%*	
Vwaza	Miombo	Open Miombo	HbVeg/Soil	Thicket	Marsh	Moist Hilly	
1984	27,991	6,674	4,668	1,449	1,548	1,338	
1994	25,893	8,544	5,597	992	1,127	1,300	
	-8%	*+28%*	*+20%*	*-32%*	*-27%*	*-3%*	
Liwonde	Miombo	Mopane	Mixed	Thicket	Marsh	Riverine	Grass/Ag.
1984	0	36,882	201	342	2,442	2,853	1,645
1994	321	34,524	193	297	2,154	1,248	5,628
	(new)	*-6%*	*-4%*	*-13%*	*-12%*	*-56%*	*+242%*

*all figures are in hectares; percent change reflects change within each class.

8.2.3 Mulanje Forest Reserve Impact Model Results

The application of change evaluation criteria for Mulanje and Zomba-Malosa were identical due to similar vegetation classes and terrain in both areas (Table 41).

Table 41. Land cover classes and their application to change evaluation for Mulanje and Zomba.

To 1994 / From 1984	Miombo & Evergreen	Grassland	Plantation	Pred. Ag. & Tea Estate	*Neutral	Soil
Miombo Woodland & Evergreen Forest	No Change	Negative	Negative	Negative	Neutral	Negative
Grassland	Positive	No Change	Plantation	Negative	Neutral	Negative
Plantation	Positive	Plantation	No Change	Negative	Neutral	Plantation
Predominantly Ag. & Tea Estate	Positive	Positive	Positive	No Change	Neutral	Negative
*Neutral	Neutral	Neutral	Neutral	Neutral	No Change	Neutral
Soil	Positive	Positive	Plantation	Positive	Neutral	No Change

*"Neutral" is outcrop and shadow.

Areas of concentrated change of all types are located along most of the Mulanje reserve boundary. These areas of change are much wider on Mulanje's southeast lobe, along much of the east side, and on the northern side of Michesi Mountain. These wide areas of change reached inside the reserve 3.4 km, 2.8 km, 1.6 km respectively. The only exception is a concentrated area of change in the interior at Chambe Basin in northwestern Mulanje. All other change appears to be randomly scattered throughout the interior of the reserve.

The overall changes manifested in the impact model in the Mulanje Forest Reserve include a large increase in the Predominately Agriculture class (242%), a decrease in some of the natural vegetation types, and an increase in the tree plantations (Table 42 and Figure 59). Grassland and Miombo Woodland comprised most of the area that was mapped as Predominately Agriculture in 1994. A decrease in Evergreen Forest (-6.4%), the vegetation class that includes Mulanje Cedar, and a decrease in Grassland (-23.3%) were detected.

Evaluated as a positive change, a small increase in Miombo Woodland was detected (450 ha). There were large increases in both Pine and Eucalyptus Plantations that may be attributed by natural regeneration or additional plantings by the Forestry Department. Areas of Grassland, Miombo Woodland, and Evergreen Forest all contributed to the areas in 1994 that were classified as Pine and Eucalyptus Plantations. Additional land was classified as Tea Estate within the reserve boundary in 1994 representing an increase of 68.2%. The locations of increases in land classified as Predominately Agriculture were in the north producing a crescent around Michesi, in the east adjacent to the large pine plantation, and to a lesser degree in the south.

These data cumulatively show significant levels of encroachment in this reserve.

Table 42. Land cover change matrix (1984-1994) for Mulanje by land area (ha).

1984 Land Cover Classes	1994 Land Cover Classes										
	MBW	EGF	GSL	PPL	EPL	AGR	TEA	SOL	SHD	OTC	Total
Miombo Woodland (MBW)	9,302	434	34	162	251	357	5	42	22	46	10,654
Evergreen Forest (EGF)	743	15,015	512	109	335	42	4	43	814	144	17,760
Grassland (GSL)	771	858	10,620	812	1,032	986	9	53	120	518	15,780
Pine Plantation (PPL)	32	108	40	252	0	3	0	0	4	108	547
Eucalyptus Plantation (EPL)	0	0	0	0	0	0	0	0	0	0	0
Predom. Agriculture (AGR)	121	4	2	26	1	1,260	0	27	0	12	1,453
Tea Estate (TEA)	0	0	1	0	0	0	20	0	0	0	22
Soil (SOL)	0	0	0	0	0	5	0	4	0	1	9
Shadow (SHD)	13	202	142	3	3	0	0	2	937	132	1,433
Outcrop (OTC)	122	55	773	10	4	45	0	33	19	4,569	5,631
Total	11,104	16,675	12,125	1,374	1,627	2,698	37	204	1,915	5,530	53,290

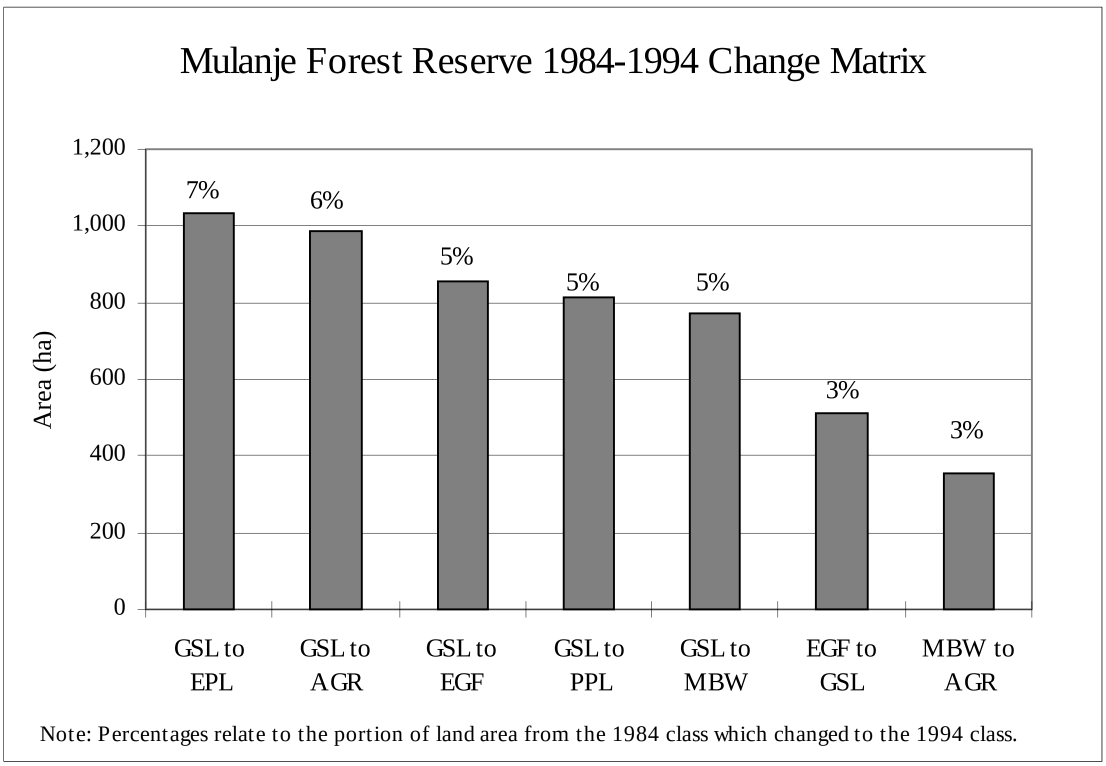


Figure 59. Land cover change (1984-1994) by class for Mulanje.

8.2.4 Zomba-Malosa Forest Reserves Impact Model Results

In general, more negative change occurs in the Zomba Plateau region compared to the Malosa mountain region due in part to large forest fires in 1994 as well as the clearing of older pine on the plantation. Other plantation changes are concentrated near the boundary. In addition, the close proximity of the Zomba urban population and the increased access provided by roads and tracks has resulted in a fuelwood supply system dependent on Zomba Mountain. In Chapter 7 some of the associated utilization is detailed, including the fuel sales trade that includes Chikanda village.

From 1984 to 1994 there was an overall decline in both the Miombo Woodland (-6.6%) and the Evergreen Forest (-3.6%) land cover classes in Zomba-Malosa (Table 43 and Figure 60). In addition an increase was detected in an area occupied by Pine Plantation (11.6%) and an increase in the Grassland class (16.8%). A changes evaluated as negative in this case was Miombo Woodland changing to Grassland, which was concentrated in the central part of the Malosa Reserve (948 ha). Also considered a negative change in the Zomba Forest Reserve, were areas of Miombo Woodland and Evergreen Forest changing to the Pine Plantation class (combined total 912 ha).

There was some positive change; areas concentrated in the northern part of the Malosa Forest Reserve changed from Grassland to Miombo Woodland (744 ha).

Table 43. Land cover change matrix (1984-1994) for Zomba-Malosa by land area (ha).

1984 Land Cover Classes	1994 Land Cover Classes							
	MBW	EGF	GSL	PPL	EPL	SHD	OTC	Total
Miombo Woodland (MBW)	6,131	677	948	312	147	2	1	8,218
Evergreen Forest (EGF)	523	2,577	303	600	0	53	0	4,055
Grassland (GSL)	744	270	1,580	200	436	3	18	3,250
Pine Plantation (PPL)	272	333	131	2,484	0	7	0	3,227
Eucalyptus Plantation (EPL)	0	0	0	0	0	0	0	0
Shadow (SHD)	5	52	29	6	0	80	0	172
Outcrop (OTC)	6	0	35	0	0	0	19	61
Total	7,680	3,909	3,026	3,602	583	145	38	18,983

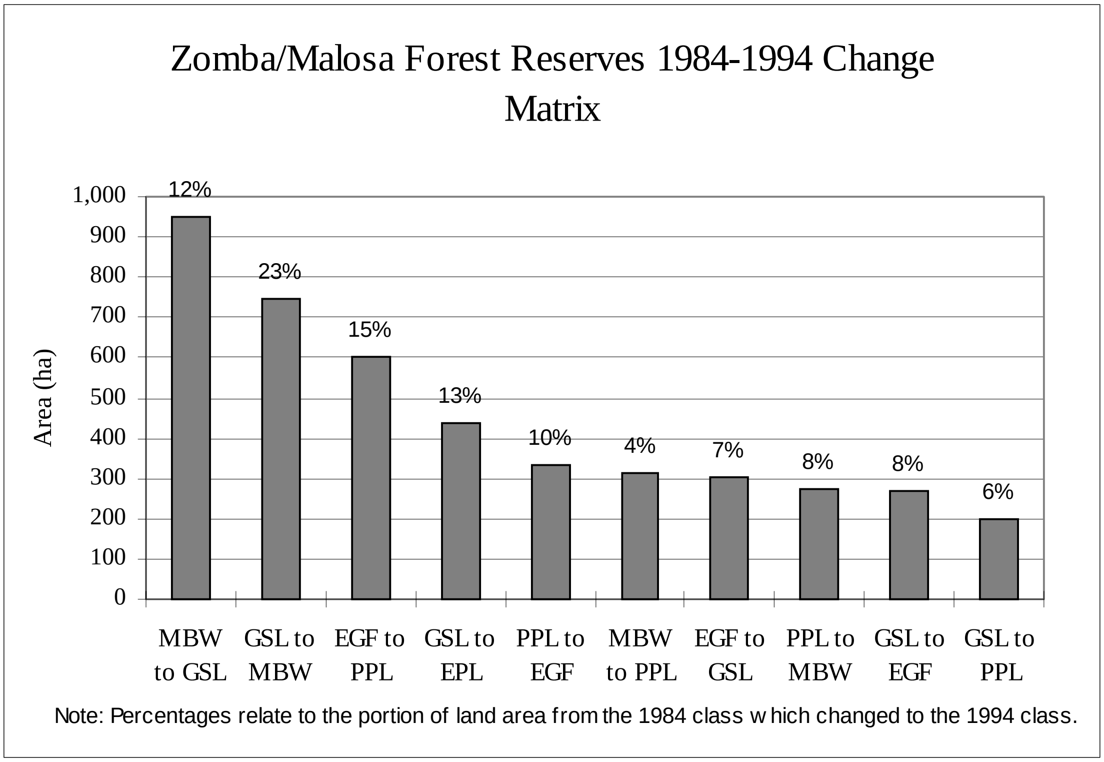


Figure 60. Land cover change (1984-1994) by class for Zomba-Malosa.

8.2.5 Liwonde Impact Model Results

Liwonde National Park land cover class fell neatly into three aggregate groups for their application to the change evaluation criteria (Tables 44 and 45).

Table 44. Land cover classes for Liwonde.

Natural Forest	Herbaceous	Neutral
Mopane Woodland	Grassland	Water
Miombo Woodland	Marsh Vegetation	Dambo/Waterlogged Area
Mixed	Predominantly Agriculture	
Riverine Forests		
Thicket		

Table 45. Land cover classes and their application to change evaluation for Liwonde.

To 1994 From 1984	Natural Forest	Natural Herbaceous	Neutral
Natural Forest	No Change	Negative	Neutral
Natural Herbaceous	Positive	No Change	Neutral
Neutral	Neutral	Neutral	No Change

NB: see Table 41 for the aggregation of these classes.

Change in Liwonde National Park was focused along the Shire River in a band that varies in width from 3 to 6 kilometers (Figure 61). In the east central part of the park where the boundary makes a distinct V shape there is a V shaped area of negative change that is attributed to encroachment. At its widest point this band of negative change is approximately 3 kilometers. The most significant change in Liwonde National Park was the decline in Mopane Woodland of 6.4% (Tables 40 and 46). Much of this Mopane loss can be attributed to the increase in the Grassland/ Predominately Agriculture land cover class, an indicator or encroachment. In the far northeast section of the park this change was related primarily to cultivation (Figure 61).

The Mopane class was complex as two classes provided difficult to separate in the unsupervised classification due to their spectral similarity. Through interpretation of the 1994 aerial photographs for this area it was determined that the area of Predominately Agriculture was concentrated in the east central section of the park. The majority of the rest of the Grassland/Predominately Agriculture class occurs in scattered areas along the Shire River but was interpreted to be Grassland.

Overall from 1984 to 1994 there was a large increase in the Grassland/ Predominately Agriculture land cover class, particularly on the east side of the Shire River and also to some extent on the west of the Shire River. These changes could result from a thinning of the Mopane Woodland, possibly due to the impact of local communities, or possibly the Park’s elephant population. Other changes in Liwonde National Park included: 56.3 % decrease in the Riverine Forest, 13.2% decrease in Thicket, 11.8% decrease in Marsh Vegetation, and 3.9% decrease in Mixed forest.

In aggregate, there was approximately five times more negative change than positive change detected in Liwonde.

Table 46. Land cover change matrix (1984-1994) for Liwonde by land area (ha).

1984 Land Cover Classes	1994 Land Cover Classes							
	MBW	MPW	RVF	THK	MRV	GPA	MXF	Total
Miombo Woodland (MBW)	0	0	0	0	0	0	0	0
Mopane Woodland (MPW)	215	31,570	315	11	48	4,656	66	36,882
Riverine Forest (RVF)	2	1,742	755	28	213	104	9	2,853
Thicket (THK)	0	51	33	258	0	1	0	342
Marsh Vegetation (MRV)	2	390	90	0	1,831	128	0	2,442
Grass/Pred.Ag. (GPA)	102	722	42	0	62	718	0	1,645
Mixed Forest (MXF)	0	50	12	0	0	21	118	201
Total	321	34,524	1,248	297	2,154	5,628	193	44,365

Note: Data from dambo/waterlogged class not included.

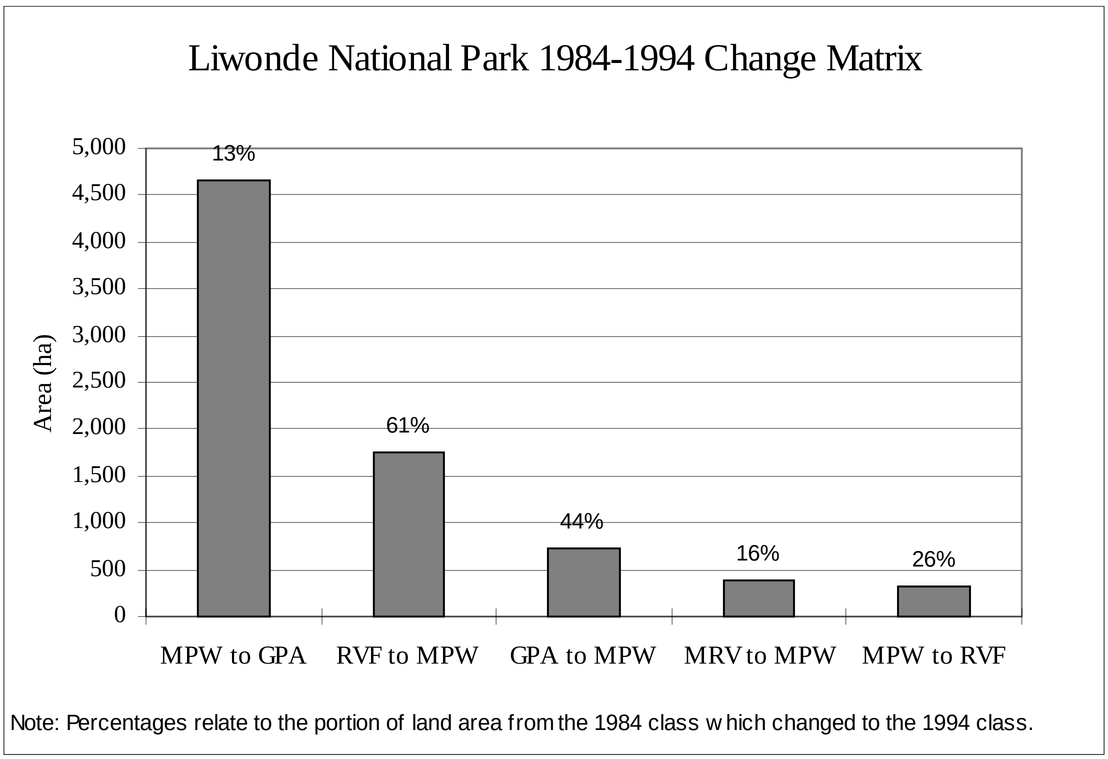


Figure 61. Land cover change (1984-1994) by class for Liwonde.

Liwonde land cover mapping was very difficult compared to the other sites as there is little variability in topographic relief, which can be an aid to classification. With dry season imagery the vegetation classes in Liwonde were difficult to spectrally separate. The result of these difficulties is a set of complex land cover classes that cannot be further defined or refined using only remote sensing methods. Unfortunately, these difficulties cause land cover classes that may appear to be distinct on the ground to be mapped as the same land cover class in the satellite imagery based classification.

8.2.6 Dzalanyama Forest Reserve Impact Model Results

The application of evaluation criteria to land cover classes for Dzalanyama Forest Reserve are similar to those of Mulanje and Zomba-Malosa, with the added characteristic of large herbaceous dambo areas and zones of much more open Miombo woodland (Table 47)

Table 47. Land cover classes and their application to change evaluation for Dzalanyama.

To 1994 From 1984	Miombo & Evergreen	Open Miombo	Natural Herbaceous	Plantation	*Neutral
Miombo Woodland Evergreen Forest	No Change	Negative	Negative	Negative	Neutral
Open Miombo	Positive	No Change	Negative	Negative	Neutral
Natural Herbaceous	Positive	Positive	No Change	Plantation	Neutral
Plantation	Positive	Positive	Plantation	No Change	Neutral
*Neutral	Neutral	Neutral	Neutral	Neutral	No Change

*Here, "Neutral" is water/shadow, and dambo/waterlogged area.

In the Dzalanyama Forest Reserve, the overall changes from 1984 to 1994 included an increase in the Broadleaf Forest (6.7%), a slight increase in Miombo Woodland (3.4%), increases in both plantation types, and a large increase in the Open Miombo Woodland vegetation class (Tables 40 and 48, and Figure 62). The first two changes were interpreted as positive. However, the large increase in Open Miombo was interpreted as a negative change due to the inferred thinning of Miombo that occurred through the decade under analysis (1705 ha changed from Miombo Woodland to Open Miombo Woodland between 1984 and 1994). This represents a significant decrease and one that represents a decrease in biomass. Therefore, this change is evaluated as negative.

Table 48. Land cover change matrix (1984-1994) for Dzalanyama by land area (ha).

1984 Land Cover Classes	1994 Land Cover Classes						
	MBW	OMW	BLF	HVG	PPL	EPL	Total
Miombo Woodland (MBW)	42,455	1,014	161	1,711	468	53	45,862
Open Miombo Wld. (OMW)	1,011	193	1	691	33	3	1,932
Broadleaf Forest (BLF)	158	0	106	0	1	0	266
Herb. Veg./ Grassland (HVG)	3,709	2,304	12	601	675	1,876	9,177
Pine Plantation (PPL)	63	0	0	0	310	0	372
Eucalyptus Plantation (EPL)	45	11	4	0	0	70	130
Total	47,441	3,521	284	3,003	1,488	2,003	362,125

Note: Data from water and dambo/waterlogged classes not included.

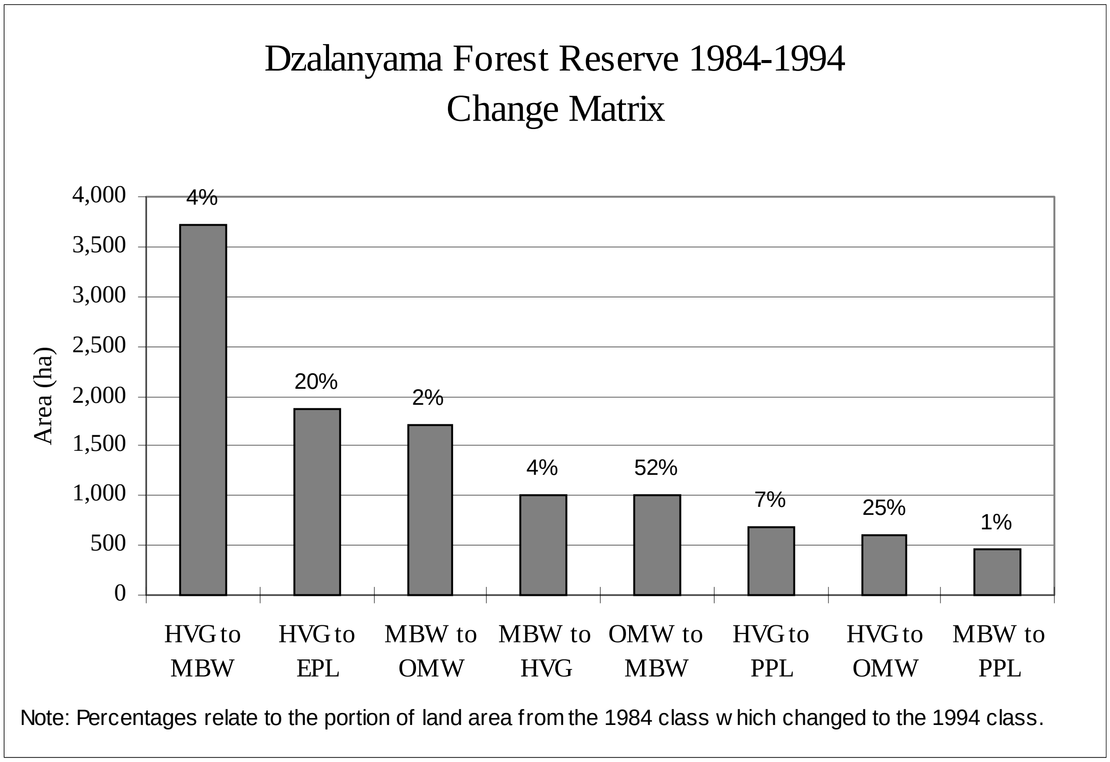


Figure 62 . Land cover change (1984-1994) by class for Dzalanyama.

8.2.7 Vwaza Wildlife Reserve Impact Model Results

The application of change evaluation criteria for Vwaza was very complex due to the greater number of distinct vegetation classes and the influences of moisture that varied considerably between 1984 and 1994 (Table 49).

Table 49. Land cover classes and their application to change evaluation for Vwaza.

To 1994 From 1984	Moist Hilly Woodland	Miombo Woodland	Open Miombo	Mtwatwa	Marsh	Herbaceous	Water & Shadow
Moist Hilly Wood.	No Change	Negative	Negative	Negative	Negative	Negative	Neutral
Miombo Wood.	Positive	No Change	Negative	Positive	Negative	Negative	Neutral
Open Miombo	Positive	Positive	No Change	Positive	Neutral	Negative	Neutral
Mtwatwa Thicket	Positive	Negative	Negative	No Change	Negative	Negative	Neutral
Marsh Veg.	Positive	Positive	Neutral	Negative	No Change	Negative	Neutral
Herbaceous Veg.	Positive	Positive	Positive	Positive	Positive	No Change	Neutral
Water & Shadow	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral

In the Vwaza Wildlife Reserve the three vegetation classes considered to have the greatest biomass showed an overall decrease: Mtwatwa Thicket, Moist Hilly Vegetation, and Miombo Woodland, –31.6%, -2.9%, and –7.5%, respectively (Tables 40 and 50, and Figures 58 and 63). These changes meet both criteria for negative change: a decrease in naturally occurring vegetation and a decrease in woodland species toward vegetation types with less biomass.

There were increases from 1984 to 1994 in Open Miombo Woodland (28.0%) and Herbaceous Vegetation/ Soil which are both considered negative as there is a decrease in biomass and woody species. There were changes in both directions between Miombo Woodland and soil land cover classes but these changes still revealed an overall decrease of 933 ha of Miombo Woodland class lost to the soil class.

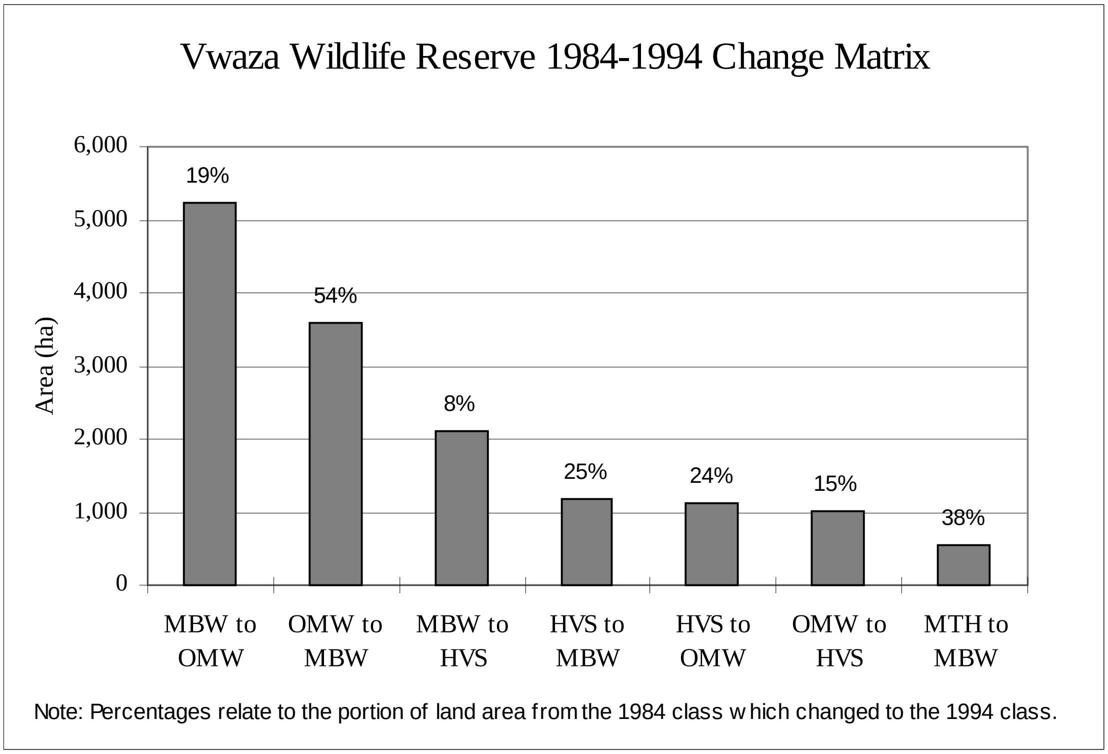
Negative change is distributed throughout the reserve with only the Zambian international border region free from change. Some concentration of negative change occurs in the northern section accompanied also by an area of positive change.

Table 50. Change matrix (1984-1994) for Vwaza by land area (ha).

1984 Land Cover Classes	1994 Land Cover Classes								
	MHW	MBW	OMW	MTH	MRV	HVS	WAT	SHA	Total
Moist Hilly Woodland (MHW)	999	207	27	0	0	50	0	55	1,338
Miombo Woodland (MBW)	128	19,568	5,242	100	226	2,100	545	82	27,991
Open Miombo Woodland (OMW)	1	3,585	2,019	0	9	1,010	50	0	6,674
Mtwatwa Thicket (MTH)	0	548	26	865	0	6	0	3	1,449
Marsh Vegetation (MRV)	0	319	63	0	873	149	144	0	1,548
Herb. Vegetation/Soil (HVS)	1	1,167	1,111	1	15	2,249	125	0	4,668
Water (WAT)	0	303	26	4	4	9	367	4	717
Shadow (SHA)	171	196	31	21	0	23	4	511	957
Total	1,300	25,893	8,544	992	1,127	5,597	1,235	655	45,343

Note: Data from dambo/ waterlogged area not included.

Figure 63. Land cover change (1984-1994) by class for Vwaza.



8.3 Impact and Access

Access results analyzed in combination with land cover change between 1984 and 1994 may help explain some of the distribution of the negative change and highlight areas where future change may be likely (Figures 64-68). Refinement of the results and the methodology may be particularly useful for future management and monitoring activities in the reserves and parks.

In Vwaza easy access and both change classes coincide very well in the northern half of the reserve. However, that positive correlation deteriorates in the south where no such relationship is apparent. In Liwonde however, there is a correlation between easy access and negative change. With the exception of the eastern central area where negative change was mapped, the negative change coincides with easy access and also along the Shire River. If the rivers or streams were deemed significant access routes, these could be added to the access model in the future. Negative change does not appear to correspond with easy accessibility in Dzalanyama. When the impact maps for Mulanje were examined in conjunction with the population maps it was found that one third more negative change is associated with high population pressure regions as opposed to low population pressure regions. In Mulanje in the Fort Lister Gap area, both concentrations of negative and positive change can be seen on the north side of the gap region. This may be attributed to high accessibility via roads and tracks within the Fort Lister Gap area but outside the reserve boundary. In the PLUS access model only roads and tracks located *inside* the park or reserve boundary were considered. An enhancement of the model to include external roads and tracks (outside but proximal to the reserve or park) may prove useful for additional impact and accessibility studies that are sensitive to these issues.

8.4 Impact and Population Pressure

The Potential Population Model results were compared with those of the Impact Model. Mulanje and Dzalanyama showed the most interesting results when the potential population pressure and impact models were compared (Figure 64). Within much of the Mulanje Forest Reserve areas of negative change correspond to areas of high potential population pressure (above the national average) as well as to many of the areas experiencing other plantations changes. Negative change areas that coincided with the high potential population pressure areas can be seen to the south, west of the Ruo River, a large part of the southeast lobe of Mulanje, and the northern perimeter of Michesi Mountain.

In Zomba-Malosa Forest Reserves, a thin sliver along the southwest section of the perimeter represents an area of above national, average, potential population pressure (Figure 45). As mentioned earlier, the influence of population of Zomba City is not represented. For this reason correlation between negative change and population pressure was not expected (Figure 65). The work of government agencies under the MEMP umbrella on the prototype EIS should remedy this weakness in the current model.

In the case of Liwonde no correlation was found between negative change and high potential population pressure (Figure 66). The major roads in proximity to Liwonde are far from the Park. This and the impact of the Shire River may result in impact further from population zones. An additional deterrent is the higher presence of DNPW scouts patrolling some areas.

The results of the Potential Population Pressure and Impact Models for Dzalanyama revealed that a large portion of the negative change occurred in the eastern belt of high potential population (Figure 67). However, small, scattered areas of negative change exist in the low potential population pressure areas as well. In the far north section of the reserve, some fairly concentrated areas of negative change are associated with areas of pine plantation change. These changes occur in areas of low potential population pressure

No portion of Vwaza Wildlife Reserve fell into the high, potential population pressure category (below national average) (Figure 48). Vwaza, as in Dzalanyama, shares an international border for which no population data were used and therefore the population pressure only considers the Malawi population influence and not that of Zambia or Mozambique.

Figure 64. Population pressure combined with change and access for Mulanje.

Figure 65. Population pressure combined with change and access for Zomba-Malosa.

Figure 66. Population pressure combined with change and access for Liwonde.

Figure 67. Population pressure combined with change and access for Dzalanyama.

Figure 68. Population pressure combined with change and access for Vwaza.

9. NATIONAL LEVEL RESULTS

The intensive analysis conducted on Level 2 sites was not possible for the remaining 82 protected areas in Malawi because of time and resources, and also due to limitations of national-level data. As Malawi moves towards analysis of environmental problems through an EIS, higher resolution digital data similar to that used in the previous chapters will become available, permitting similar analysis for larger areas.

PLUS analysts derived alternative approaches for the national level analysis and modeling. These do not overcome the data resolution limitations, but they do provide products that provide a foundation for more focused efforts in the future. National level analyses of Agricultural Suitability, Erosion Hazard, Potential Population Pressure, and Change or Impact (1972/1973 to 1990/1991) were carried out for all protected public land in Malawi. In the national-level models, already existing digital data were used in the calculations with the exception of the boundaries of all the public lands which were digitized from the 1:250,000 Survey Sheets as requested by the Lands Steering Committee. Most of these data layers were at a coarse resolution and therefore provide very generalized information. In some cases, they allow for only an approximation of the original models.

9.1 Agriculture Suitability Model for All Protected Areas

9.1.1 National Agricultural Suitability Model Design

The model for agricultural suitability at the national level was based on only three input layers: *soil units*, *slope steepness*, and *length of the growing period*. A digital version of the FAO-UNESCO Soil Map of the World) had an original scale of 1:5,000,000 (Figure. 59). This map and the accompanying documentation were used.[61] Information extracted from the FAO documents provided a general sense of agricultural suitability for *each soil unit*. Table 51 outlines which soils in Malawi were designated as suitable or not suitable for agriculture.

LREP agro-climatic digital maps provided information at a national level for *the length of the growing period* (Figure 70). This data layer was the only digital national-level LREP map available (original scale 1:250,000) and provided more detailed information than the other two input layers. Growing periods that were between 120 to 270 days a year were considered suitable; growing periods above or below these limits were considered not suitable for agriculture.

Slope steepness was derived from the United States Geological Survey (USGS) 1.0 km DEM (Figure 71). In this model slopes lower than 13% were considered suitable for agricultural activities and all steeper slopes were mapped as unsuitable.

[61] a) FAO-Unesco, 1974. Soil Map of the World. Volume I. Legend. FAO-Unesco, Rome.
b) FAO, 1988. FAO-Unesco Soil Map of the World, Revised Legend. World Soil Resources Report 60. FAO, Rome.

Figure 69. Soils of protected areas (FAO 1:5,000,000)

Figure 70. Length of the growing period for protected areas (LREP 1:250,000).

Figure 71. Digital elevation model of Malawi (USGS 1.0 km).

Table 51. Agricultural suitability according to FAO soil classification.

1st Level Class	2nd Level Class	Agricultural Suitability
Acrisols	Haplic Acrisols	Not Suitable
	Humic Acrisols	
Leptosols	Eutric Leptosols	Not Suitable
Luvisols	Haplic Luvisols	Not Suitable
	Chromic Luvisols	
Cambisols	Chromic Cambisols	Suitable
	Ferralic Cambisols	
Gleysols	Eutric Gleysols	Suitable
Lixisols	Haplic Lixisols	Not Suitable
Phaeozems	Calcaric Phaeozems	Suitable
Planosols	Eutric Planosols	Not Suitable
Regosols	Eutric Regosols	Not Suitable
Vertisols	Eutric Vertisols	Not Suitable

9.1.2 National Agricultural Suitability Model Results

The model results are binary; areas are suitable when all three criteria are met and are mapped as not suitable when any one criterion is not met (Figure 72). These results show that less than 10% of Malawi's protected land is suitable for agriculture. The accuracy and utility of this figure is severely limited given the extremely generalized input data layers.

Manual analysis of Land Resource Evaluation Project (LREP) data (at a much better 1:250,000 scale) suggest as much as 30% of protected land (600,000 hectares) may be suitable for agriculture under traditional management.[62] Unfortunately, digital LREP soils data are not yet available for all of Malawi, making a spatial representation of such an analysis a considerable task. For the time being, these two conclusions remain unreconcilable. However, as mentioned earlier, digitizing LREP analog products is a priority of the prototype EIS and therefore the issue may be resolved in the future.

9.2 Erosion Hazard Model for All Protected Areas

Four scenarios were simulated for the erosion hazard model: Present Cover, Bare Soil, and tm and itm Agriculture Scenarios. The erosion hazard model considers vegetation

[62] See Eschweiler, J. 1993. Malawi Land Use Issues. World Bank, Lilongwe/Kortenhoef.

cover, climate, soils, and topographic characteristics. *Energy interception*, or I values were assigned to each of the Forestry/Satellitbild land cover classes.[63] National-level I values were estimated in a similar manner to which they were estimated and assigned in the Level 2 model. This was done according to percent canopy cover, understory vegetation, and ground litter associated with each land cover class. *Rainfall energy* was derived from the mean annual rainfall obtained from the LREP agro-climatic map and associated database which was available for at the national level.

Figure 72. Agriculture suitability model results for all protected areas.

National-Level soil information was limited to the FAO soils map and documentation. In comparison to this, for the Level 2 analysis the finer resolution LREP soils and physiography map including a database with over 40 variables was used. This difference in the detail of soils information between the two levels is readily seen in the Zomba-Malosa Forest Reserves (Figures 73 and 74). Unfortunately, the LREP soils and physiography maps were not available in digital form for all of Malawi. The Erodibility or F factors for FAO soil types were determined by correlating the FAO soil units with LREP soil groups using the LREP Field documents (Table 52).[64] It was assumed the erodibility was higher for the tm scenario than for the itm scenario and therefore the F factor for itm was one unit higher than the tm F factor. The following F factors were used:

Table 52. Soil erodibility factors used for national erosion hazard modeling on protected areas.

FAO Soil Type	tm F factor	itm F factor
Acrisols, Gleysols, Lixisols, Leptosols, Luvisols, Phaeozems, and Regosols	4.5	5.5
Cambisols, Planosols, Vertisols	3.5	4.5

As in the Level 2 analysis, the topographic factor consists of two parts; slope steepness and slope length. The former was derived from the national DEM (1 km resolution). Slope length was not calculated. However, estimated constants were used for each scenario to simulate differences in management practices. The slope lengths for the Present Cover, Bare Soil, tm Agricultural, and itm Agricultural Scenarios were set at 10m, 30m, 20m, and 10m respectively. Figure 73 demonstrates the effect of scale and spatial resolution on slope information from the different data sources (1:50,000 Survey Sheets, 1:250,000 LREP soils/Physiography Maps, 1 km USGS DEM).

The extremes in erosion risk are evident in Figure 75, which shows the contrast between the Present Cover and Bare Soil scenarios. Under conditions of cultivation similar to

[63] Satellitbild, 1993. Forest Resources Mapping and Biomass Assessment for Malawi. Satellitbild, Lilongwe.
[64] Paris, S., 1990. Erosion Hazard Model (modified SLEMSA). Field Document No. 13 (second version). Land Resources Evaluation Project, Malawi Government Ministry of Agriculture, Land Husbandry Branch; UNDP; FAO.

those practiced by the majority of smallholders, 60% of Malawi's protected land has an unacceptable erosion risk (Figure 76).

These maps provide insight to the risk of erosion on Malawi's soils, but the results should be treated as indicators for more intensive work rather than as absolutes. Land managers require more detailed analysis prior to making local-level land use and management decisions. The intensive analysis done on the five Level 2 areas provides much more insight into the nature of the resource in those reserves, as is demonstrated in Figure 77 which compares the Mulanje erosion hazard at the Level 2 and at national levels.

Figure 73. Scale and spatial resolution: slope in Zomba-Malosa from various sources.

Figure 74. Comparison of LREP soils map with FAO national soils map.

Figure 75. Erosion hazard under traditional management for all protected areas.

Figure 76. Erosion hazard under improved traditional management for all protected areas.

Figure 77. Comparison of erosion hazard model output with Level 2 and national data.

9.3 Population Pressure for All Protected Areas

The population pressure models outlined for Level 2 in Chapter 6 are identical to those used at the national level. See sections 6.1.1 and 6.2.2 for design details of both the direct and potential population models.

The results of direct population pressure are depicted in Figure 78. A comparison between protected areas is not possible in this model because the total population rather than the density around the perimeter of the reserve was used. Therefore, protected areas with large areas may have higher total populations around them than smaller reserves, but the pressure may not be as great.

A much better tool for comparison is the Potential Population Pressure Model (Figure 79) because it is focused on points within protected area boundaries relative to the population on the outside.

This model shows that population pressure on protected area is much higher in the south and central regions where the density, based on the 1987 census, is over 100 people per square kilometer, than in the north where it is 35/km^2. However, based on the national maps of these pressure levels, it is clear that population is not evenly distributed. It is extremely high around certain reserves; small reserves, with their limited perimeter and land area, are disproportionately affected.

Figure 78. Direct population pressure.

Figure 79. Potential population pressure.

9.3.1 Impact Model (Land Cover Change)

An analysis of land cover change from 1972/1973 to 1990/1991 was also conducted, using Forestry/Satellitbild land cover maps derived from manual interpretation of hard copy satellite images (see Figure 80 for the 1991 land cover).[65] The national level Impact Model revealed that agricultural expansion impacted 4% of Malawi's land during that time, 80% of which came from natural woodland areas. Changes are shown by land area in Table 53 and Figure 81, and classed as percentage positive, negative and neutral in Table 54. This change analysis of land cover classes spanned an 18 year period but used only two points in time; therefore little can be said about trends of change. The changes that were detected probably did not occur linearly over the period and therefore no realistic, constant annual rate of change for processes such as deforestation can be estimated (Forestry/Satellitbild, 1993). However, analysis by the Ministry of Energy and Mines indicates that the rate of decline in forested areas has reached 3.5% per year.[66]

Table 53. Change matrix for Malawi's protected areas (1973-1991). Area is in hectares.

1972/73 Land Cover Classes	1990/1991 Land Cover Classes											
	EGF	MBW	EPL	PPL	OPL	LGA	WAT	NC	GDS	AGR	BUA	Total
Evergreen Forest (EGF)	48,900	1,600	200	2,400					2,800	700		56,600
Miombo Woodland (MBW)	2,400	1,225,500	10,000	22,800	100	5,000	200		6,500	59,200		1,331,700
Eucalyptus Plantation (EPL)			600	200						100		900
Pine Plantation (PPL)	200	300		37,900					900	100	100	39,500
Other Tree Plantation (OPL)		300		300								600
Logged Area (LGA)												0
Water (WAT)		100					1,300					1,400
Not Classified (NC)	1,400	8,000	500	32,800			700		270,800	22,200		336,400
Grass/Dambo/Savanna (GDS)												0
Partially Agriculture (AGR)												0
Built-up Area (BUA)												0
Total	52,900	1,235,800	11,300	96,400	100	5,000	2,200	0	281,000	82,300	100	1,767,100

Note: The 1972/1973 MSS Land Cover Map was limited to forested areas. Changes to the resulting "Not Classified" category remain in the change matrix table, but were omitted from the graph for clarity. This affects the GDS, AGR, and BUA classes. The AGR class includes both intensive and extensive agriculture classes.

[65] Satellitbild, 1993. Forest Resources Mapping and Biomass Assessment for Malawi. Satellitbild, Lilongwe.

[66] Openshaw, K. 1996. Urban Biomass Fuels: Production, Transportation, & Trading Study. Alternative Energy Development/Ministry of Energy and Mines, Lilongwe

Figure 80. Land cover in 1991 for protected areas.

National-Level change was evaluated in a similar way as described in Chapter 8 for the Level 2 sites but using the digital Forestry/Satellitbild land cover maps. The results are depicted can be seen graphically in Figure 81 and in terms of percentage of total protected land area in Table 54. Very little change was interpreted as positive, and 6% of protected land experienced negative change.

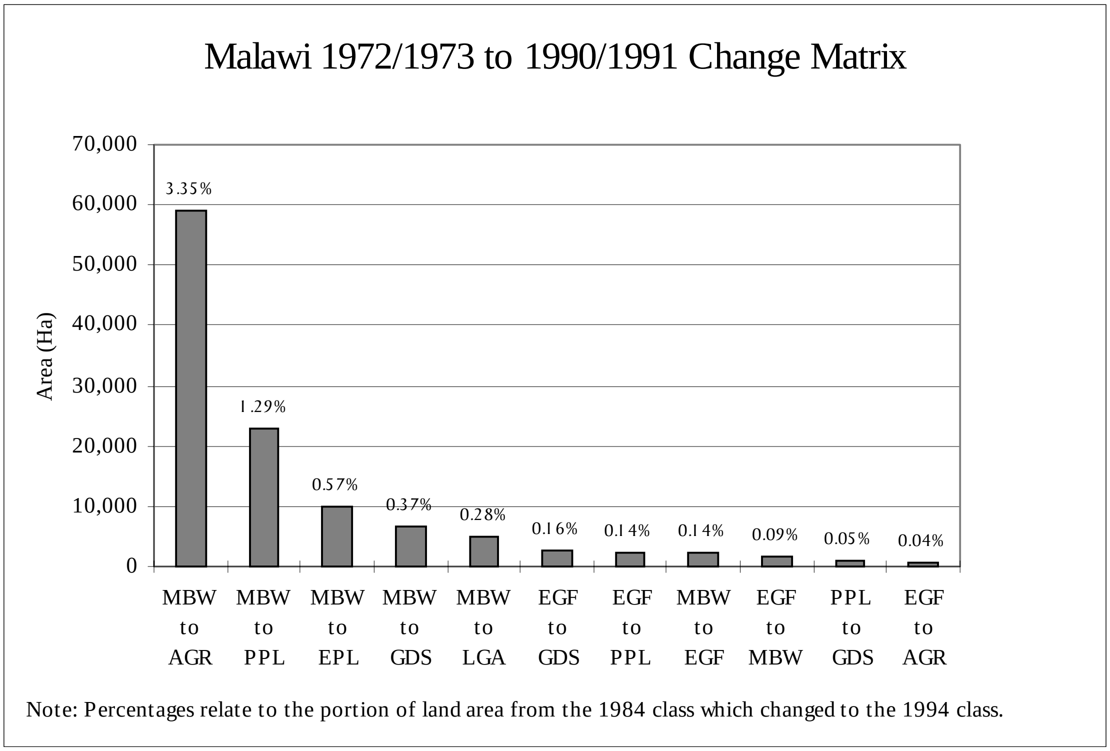


Figure 81. Land cover change analysis on all protected areas (1973 - 1991).

Table 54. National protected areas land cover change.

	Area (ha)	Percent of Total Area
No Change	1,323,797	74
Negative	109,961	6
Neutral	352,899	20
Positive	1,705	0
Total	1,788,362	100

The detail provided at the national level for land cover classes is quite different and often more generalized than the Level 2 analysis Figures 82 and 83 demonstrate the effect of the different methods used (manual interpretation versus digital classification of land cover and change detection) and the effects of different scales of the data.

Figure 82. Comparison of 1994 land cover with 1991 national map in Vwaza.

Figure 83. Comparison of 1984-1994 land cover changes with 1973-1991 national map.

10. INCORPORATING RESULTS INTO POLICY MAKING

Each of Malawi's protected areas was created for reasons that were compelling at the time of gazettement. In many cases those rationale still hold while in others the focus may have changed but the underlying goal remains the same (i.e. the shift from preservation to conservation on what were Game Reserves and are now Wildlife Reserves). Nonetheless, the land pressure in Malawi today is much greater than when the reserves and parks were created. That pressure is so great it has forced a reevaluation of all tenure systems and utilization practices in Malawi. The Land Policy Reform Commission will assess all of the information available and make land policy reform recommendations to the government in 1998. Soon after, the government will begin reforming current land policy. This report opens with recommendations that are meant to support the design of new policy.

The role and management of forest reserves, national parks, and wildlife reserves may be refined or even redefined through this process. However the underlying rationale for protection will remain. Moreover, the pressure for access to land and resources in these areas will continue, and in some cases, requests for tenure change will be brought forward. In the same regard, tracts of customary and estate land may also come under scrutiny and may also face demands for change. For this reason, the Lands Steering Committee requested a proposal for a framework for decision making to address requests for change in tenure for specific tracts of (Figure 84).

Figure 84. Framework for decision making.

10.1 Framework Concepts

10.1.1 Coordination and Decision Making

The framework flows from the point that a proposal to change the tenure of a specific tract of land is brought to the government's attention. The government's first step is to convene a team of national-level stakeholders and experts (such as the Lands Steering Committee) whose first task is to identify all local stakeholders and provide them with the logistical means to form a Local Advisory Committee. The Local Advisory Committee, with expert assistance from the Lands Steering Committee, participates in every step of information gathering, analysis and decision making throughout the rest of the framework.

10.1.2 Major Phases of Analysis

There are two distinct phases of analysis in this proposed framework. The first phase is a *environmental suitability analysis* (shown in the upper portion of Figure 84) based on the current physical and socio-economic conditions associated with the tract of land in question and the affected surrounding area as well as the potential impacts that will result from the proposed changes.[67] The second phase is a *cost-benefit analysis* of the current tenure and the proposed changes. This phase is shown in the bottom part of Figure 84. Environmental suitability is evaluated prior to any economic analysis, particularly for protected land, as it is much more difficult to restore natural conditions than to remove them.

10.1.3 Major Decision Points

The decision to be made after the first phase is whether or not the land is environmentally suitable for change, based on the review of the analysis conducted in the preceding technical steps. For suitable land, the second phase of analysis addresses whether or not there are higher returns from the proposed change in economic terms. For unsuitable land, the economics of protection are evaluated for feasibility in practical and economic terms.

There is a secondary decision point for land deemed environmentally suitable with higher potential returns from the proposed new tenure. If external compensation is available for protected lands that are suitable for agriculture, it could be used to indemnify those bring pressure for agricultural development. For example, in some cases pressure to protect land which proves to be both environmentally and economically suitable for agricultural development may result in an offer of "external non-development compensation" to continue protection. It is assumed such compensation would have to counter any potential lost revenues that would accrue from actually developing the land for agriculture.

10.1.4 Contributors to the Design of the Framework

The ideas behind the design of the proposed framework were borrowed from a multi-sectoral memorandum issued to the Commission on Land Policy Reform by the Inter-Agency Working Group on Protected Areas, with representatives from Malawi government agencies currently addressing issues in Malawi's reserves and parks. Several concepts from existing legislation and policy as well as recently proposed policy from various agencies were used as a guide. This includes the Environment Management Act and its Environmental Impact Assessment, as well as the community involvement provisions under recently developed Forestry and Fisheries policies. [68] The framework also incorporates a number of recommendations from members of the Ministry, the Lands Steering Committee.

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[67] This could include a large area particularly where downstream effects are possible, such as is the case where urban water supply is at risk, or where erosion could influence sedimentation rates in Malawi's lakes.

[68] a) Inter-Agency Working Group on Protected Areas. 1997. Protected Areas: Their Role and Future in Malawi's Land Budget. A Memorandum Submitted to the Presidential Commission of Inquiry on Land Policy Reform. Lilongwe.

b) Environmental Affairs Department. 1997. Guidelines for Environmental Impact Assessment. GOM, Lilongwe.

c) Ministry of Natural Resources. 1996. National Forest Policy of Malawi. GOM, Lilongwe.

d) GOM, 1992. National Parks and Wildlife Act, No. 11 of 1992. Parliament of GOM, Zomba; and GOM, 1994. National Parks and Wildlife (Fees) Regulations, 1994. Government Notice No. 85 of the Malawi Gazette Supplement. Parliament of GOM, Zomba.

e) Department of Fisheries, 1996. National Fisheries Policy. GOM, Lilongwe.

10.1.5 Local Advisory Committee

The "Local Advisory Committee" would include members of the local community as well as representatives of all affected local parties (i.e. local agency representatives, private interests, estate owners, etc.) It is critical that no stakeholder group is omitted – otherwise an opportunity for necessary consensus building may be missed. The blue portions of the decision pathway in Figure 84 indicate where local stakeholders contribute to the review and decision making process. Their points of intervention represent the decision points in the framework. Note that the flow of decisions goes down, but the involvement of local stakeholders in the decision process is the first step, and in fact part of every step throughout the framework.

10.1.6 Upper Regulatory Body

The "Upper Regulatory Body" is assumed to be the Ministry, represented by the Lands Policy Planning Unit and an advisory team of experts drawn from the Lands Steering Committee. The composition of this team would reflect all stakeholders (i.e. representatives from the legal, socio-economic, environmental, agricultural and technical sectors as well as local community representation). The Lands Steering Committee team of experts is involved at each review and decision point. They represent the "return loop" to the Upper Regulatory Body. The National Council of the Environment and its Technical Committee would help ensure the environmental suitability analysis meets the standards required by an Environmental Impact Assessment.

The Lands Steering Committee in its current form consists of members and visitors of more than 60 organizations with a stake in land issues. Many are government line agencies, but many more are research institutes, non-government organizations, and international organizations. In the framework, it is assumed that such a body, chaired by the Ministry, would be able to allocate relevant expertise to assist the "Local Advisory Committee" in reviewing pertinent information and coming to a decision through broad consensus.

10.1.7 Relationship to Management Strategies

The framework focuses only on the change in tenure decision. However, it is designed to also provide baseline environmental and economic analysis to the local and national advisory groups recommended in most of Malawi's recently developed environmental polices. This would allow integrative resource management strategies such as the Model Forest, Joint or Adaptive Management, and CBNRM, if already in place, to assist in forming the Local Advisory Committees. [69] If no integrative resource management efforts are in place, the Local Advisory Committee, but virtue of its broad representation, would be ideal in assisting its formation.

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[69] a) Shinder, B., Steel, B. and P. List. 1996. Public judgement of adaptive management: a response from forest communities. Journal of Forestry 94 (6) 4-13.
b) SADCC, 1997. Proceedings of the International Model Forest Workshop, Lilongwe 10-12 March 1997. SADCC Forestry Sector Technical Co-ordination Unit, Lilongwe.

10.2 Framework Issues

10.2.1 Receiving a Request for Change in Land Tenure
As currently diagrammed, the framework does not attempt to structure the form or direction of requests that may be made to the Ministry concerning land tenure change. It was assumed that these mechanisms already exist, and if, in their current form, the procedures behind such requests are in need of modification, proposals will be brought to the Land Commission and/or the Ministry.

Participants at the Closing Seminar raised the concern that the framework might be "top down" because the first mobilization point is the convening of the Upper Regulatory Body, in this case the Lands Steering Committee. It was explained that the current flow of requests to the government from villages moves from local village committees to local area committees, to district development committees, eventually reaching the Minister.

The proposed framework *does not* in any way supersede or circumvent that process, or any other method of proposing changes. It actually picks up at the final stage of those existing processes – when the Ministry is advised that there has been a request for land tenure change on a specific tract of land. This request could come from the administrative process noted above, or from any other accepted process. The intent of this framework is to include local stakeholders in *every* step of the land tenure change, decision-making process. It is *not* to dictate the means of raising or challenging such a request.

The framework in Figure 84 picks up from where the request is made. It is the decision making process that flows with the arrows down the chart. Local participation actually begins at the top, being mobilized as the first step by the Ministry. It continues through every stage of the decision making process. In addition, the Lands Steering Committee (or some similar multi-sectoral national body) has influence at every step of the process. The intent is for the Steering Committee to provide national-level consensus and expertise to assist the Local Advisory Board (local representatives of all stakeholders) in making an informed decision.

10.2.2 Bound by Law or by Practice – the Case for Involving All Stakeholders
Land policy changes may be made as a result of the Land Reform Programme. If changes in legislation follow, people will be affected by them and even *bound* by them in a legal sense. Nonetheless, those changes would be much more practical to implement and palatable if they were supported by all interested parties.

Often it is assumed that forcing representatives of diverging interests to negotiate a compromise will result in all parties losing. However, there is a great deal of evidence suggesting that involving all parties, including those impacted by "downstream effects" commonly results in gains on all sides.

It is for this reason that the basis of the framework lies in assembling representatives of local stakeholders to participate in every stage of the information gathering and decision making process, and that they be supported by experts from any relevant national sector. Such a design also has natural management implications by providing a forum from which a consensus management team can be built, or drawing from such a team if it already exists.

10.2.3 A Framework for Public Land Only?

Representatives of the Protected Areas Group, the Land Commission, and within the Ministry requested that any proposed framework be relevant to *any* potential changes in land tenure. Their reasoning was that while the environmental risk of removing protection may be great, there are other situations that might warrant tenure change on estate or customary land where the impacts of change (or lack of change) might also prove detrimental. This framework attempts to meet that request, using as a basis the themes of environmental suitability of land for tenure change and broad representation and involvement of local stakeholders in the decision process.