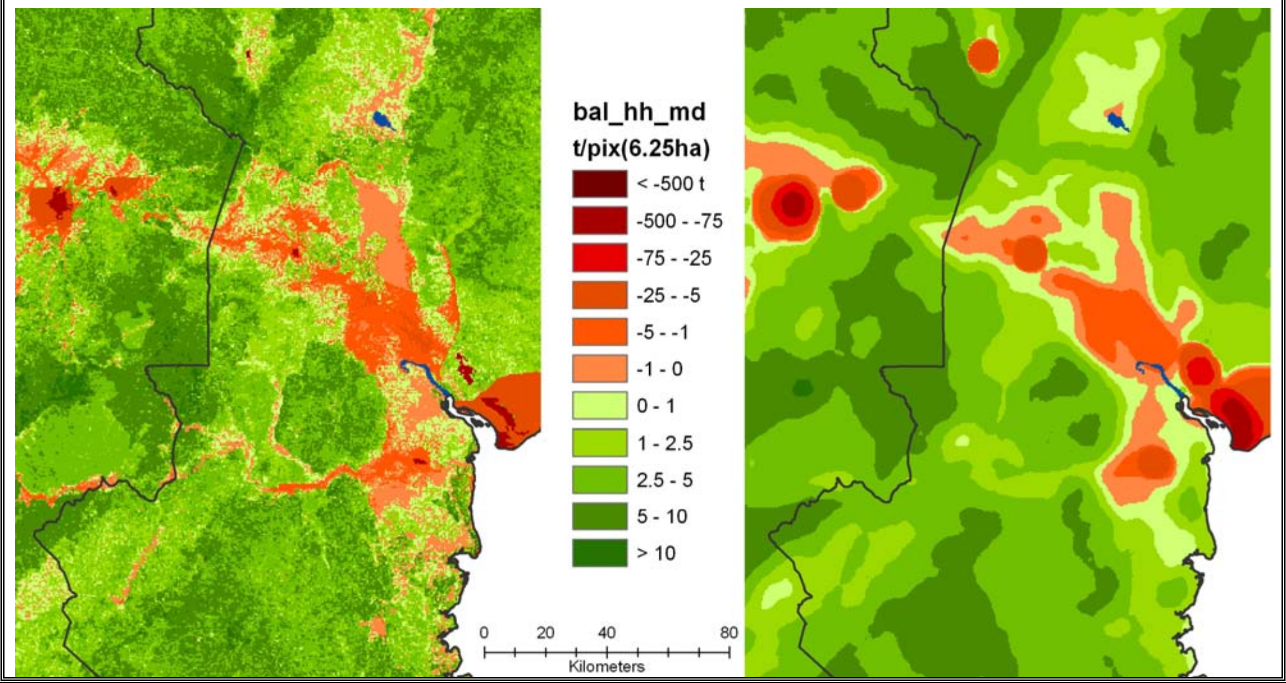
República de Moçambique
Ministério de Agricultura
Direcção Nacional de Terras e Florestas

WISDOM Mozambique

Wood energy supply/demand analysis applying the WISDOM methodology



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COOPERAZIONE ITALIANA

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Contents

Acronyms

RC	Reporting Consultant
WISDOM	Woodfuel Integrated Supply/Demand Overview Mapping (methodology)
PA	Posto administrativo (INE subnational administrative level)
DNTF	Direcção Nacional de Terras e Florestas
LFFB	Lei de Florestas e Fauna Bravia
AIFM	Avaliação Integrada De Florestas De Moçambique
GIS	Geographic information system
ad t	Air-dry tones, at 12 % moisture
od t	Oven-dry tones, at 0 % moisture
UEM	University Eduardo Mondlane (Maputo)
DTM	Digital Terrain Model
UIF	Unidade de Inventario Florestal (Forest Inventory Unit) of DNTF

Acknowledgements

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Given the multi-disciplinary character of wood energy, the development of the WISDOM geodatabase could not be possible without the contributions of many persons from different units of the *Direcção Nacional de Terras e Florestas* (DNTF), from the University Eduardo Mondlane, from the *Instituto Nacional de Estatìstica* (INE) and from several other external institutions.

Among them, the authors wish to acknowledge the contributions of Dr. Mario Paulo Falcao, Dr. Almeida A. Sitoe and the support of Giorgio Andreoli, Agriconsulting.

1. Introduction

1.1 Project objectives

Main objective of Wood Energy Component of the Consolidation Phase of the Integrated Assessment Of Mozambican Forests (AIFM) is to enhance the capacity of the country in the formulation of sound wood energy policies and the sustainable management of biomass resources through the development of a wood energy information system for the production of geostatistical data and thematic maps describing and quantifying the national bioenergy production and consumption and its potentialities.

Overall objective of the consultancy of the Biomass Modeling Expert was to assist in the implementation of a woodfuel demand and supply analysis for Mozambique applying the WISDOM[1] methodology, in support of sustainable management of woody biomass resources and wood energy / bioenergy development planning.

In this context, and in collaboration with the staff of the Forest Inventory Unit (UIF) of the DNTF, the Biomass Inventory Expert, and the Database/GIS Expert, the specific tasks to be performed by the Biomass modeling Expert while introducing and implementing WISDOM Mozambique were the following:

- Perform an evaluation of the supply and demand balance of biomass for the entire country including an overview of the present situation and the development of future scenarios.
- Contribute to the development of the current Information System installed at UIF in order to integrate the biomass data in the system and to facilitate the utilization of the data and models for planning purposes.
- Ensure the transfer of know how and knowledge related to biomass studies to the UIF personnel so that the national counterparts in future will be able to carry out similar studies in an independent manner.

1.2 Activities

First mission

In the first mission of three weeks (29 November – 20 December 2007), the main objectives were to:

(i) review data and maps produced by AIFM and provided by institutional partners for the development of the supply and demand modules,

(ii) define and initiate the procedure for the creation of the geostatistical dataset on the distribution and pattern of actual/potential biomass productivity available for energy use and of current consumption;

(iii) provide technical and theoretical backstopping to UIF staff in relation to WISDOM implementation and related wood energy aspects and conduct the analysis to the extent possible with the available dataset;

(iv) define follow-up action for the additional data procurement and for the completion of the analysis.

Mission time was invested as follows:

- Analysis of the available spatial and statistical information,
- Identification, procurement, reviewing and integration of additional layers, concerning land cover and vegetation density aspects, stocking and productivity of inventoried and non-inventoried categories, woody residues produced by forest industries, fuelwood and charcoal consumption in the residential, industrial

[1] The Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) methodology is the fruit of collaboration between FAO's Wood Energy Programme and the Institute of Ecology of the National University of Mexico (FAO, 2003). At national level, the WISDOM approach has been implemented in Mexico (FAO, 2005b), Slovenia (FAO, 2006a) and Senegal (FAO, 2003). At subregional level, WISDOM was implemented over eastern and central Africa countries (Burundi, DR Congo, Egypt, Eritrea, Kenya, Rwanda, Somalia, Sudan, Tanzania and Uganda) (FAO, 2006b) and over the countries of SE Asia (Cambodia, Malaysia, Laos, Thailand, Vietnam and the Yunnan Province of China) (FAO, 2007).

and commercial sectors, etc.

- Definition and implementation of step-by-step analytical procedures in order to clarify/formalize the processes and to allow revision, updating of the specific data layers and to provide on-job training to UIF staff.
- Discuss with partners (Universities, Forestry and energy agencies) about the overall WISDOM approach and on the specific parameters to be assessed concerning biomass stocking, productivity and consumption patterns in order to obtain additional advise and reference material

Second mission

The second and conclusive "WISDOM" mission took place from 4 to 28 March 2008.

This second phase of activity was dedicated to the development of the WISDOM geodatabase on the basis of the information gathered and produced.

Under the coordination of the reporting Biomass Modeling Expert, the action was divided into thematic/operational components followed specifically by the Biomass Inventory Expert (stock and increment), by the Database/GIS Expert (population mapping and overall geodatabase management), by the Head of the Inventory Unit (assessment and location of wood industries' residues) and by Unit members (fuelwood consumption in tobacco drying; game reserves data; etc.).

The work was conducted mainly at the Forest Inventory Unit of DNTF.

The results and methods of WISDOM Mozambique were presented at the Seminar on Biomass that was held on 24th March at the University Eduardo Mondlane; Faculty of Agronomy and Forest Engineering, with the scope of initiating a discussion group in support of the formulation of the National Biomass Plan. The day-long seminar, that saw the participation of representative from various sectors and accreted the most knowledgeable persons on Mozambican wood energy system, has been an excellent opportunity to present WISDOM and discuss its important role in the framework of the Plan under formulation. The presentation has been successful, generating keen interest and a relevant role in the subsequent discussions.

On 27th the results of the activity were presented at the DNTF to a wide representation of the various departments.

2 Methodological issues

2.1 Key features of wood energy systems

Wood energy is not a self contained and delimited sector and does not present a well defined institutional structure responsible for its planning and control. It rather sits at the intersection of many different sectors, disciplines and institutional competences, each of which has its specific folder of responsibilities and planning tools but none of which perceives a direct responsibility towards the development and monitoring of sustainable wood energy systems (FAO, 2008).

Critical challenge in wood energy planning is to overcome the fragmentation of competences and responsibilities that characterize the sector and to achieve an adequate level of integration and collaboration among the sectors involved.

The energy sector sometimes uses planning tools that include wood energy elements, such as the Long-range Energy Alternatives Planning (LEAP) model (FAO, 1998a; SEI. 2000), but these are analyzed mainly from consumption perspectives, leaving out most of the issues related to woodfuels supply sources and production sustainability.

Forest management tools, on the other hand, deal with production sustainability (FAO, 2002b), but focus mainly on timber concessions and industrial roundwood production rather than woodfuel production, in spite of the paramount importance of woodfuels among forest products. Moreover, forest management is limited to forest formations, while a significant fraction of all consumed woodfuels is produced outside forests and other wooded lands (i.e., shifting cultivation areas, land use conversions, agroforestry, farmlands, etc.) or from harvesting and industrial forestry residues.

Specific wood energy problems are commonly dealt with by means of detailed local studies, such as the area-based woodfuel flow analysis (FAO, 1997a; FAO, 1998b; FAO, 2000; FAO, 2001b), whose results support local planning or are expanded at national level to guide energy action and interventions. Many local studies and project, if not most, were focused on specific cities and on their fuelwood and charcoal supply zones, with the specific scope of supporting sustainable resource management and the continued supply of woodfuels (Bertrand et al, 1990; ESMAP,1993; Chaposa, 1999).

These studies provide adequate information and effectively support the formulation of sound policies, but they are expensive and time consuming. Their cost makes them limited in coverage and sporadic, thus failing to provide the national overview that is necessary for the formulation of national policies in respect of renewable energy potentials, forestry and energy planning, inventories of greenhouse gases, etc.

Moreover, these local studies confirmed the local heterogeneity of wood energy situations and helped to mark out the fundamental characteristics of wood energy systems, which may be summarized as follows:

Inter-sectoral. Wood energy systems sit at the crossing of forestry, energy, agriculture and rural development and sound policy and planning can only be achieved if these different “souls” are integrated.

Interdisciplinary. The range of science and techniques that are involved in the analysis of wood energy systems include silviculture and forest management, agronomy, physics, chemistry, engineering, etc..

Geographical specificity. The patterns of woodfuel production and consumption, and their associated social, economic and environmental impacts, are site specific (Mahapatra and Mitchell, 1999; FAO/RWEDP, 1997; FAO, 2003a). Broad generalizations about the woodfuel situation and impacts across regions, or even within the same country, have often resulted in misleading conclusions, poor planning and ineffective implementation.

Heterogeneous demand sectors. Main current users of woodfuels are rural and, to a lower extent, urban households but there are conspicuous levels of consumption in the commercial, public, industrial and energy sectors that need careful evaluation and accounting.

User adaptability. Demand and supply patterns influence each other and tend to adapt to varying supply patterns and resource availability. This means that quantitative estimations of the impacts that a given demand pattern has on the environment are very uncertain, and should be avoided (Leach and Mearns, 1988; Arnold et al., 2003).

Heterogeneity of woodfuel supply sources. Forests are not the sole sources of woody biomass used for energy. Other natural or domesticated landscapes, such as shrublands, farmlands, orchards and agricultural plantations, agroforestry, tree lines, hedges, etc. contribute substantially in terms of fuelwood and, to a lesser extent, of row material for charcoal production.

Forests remain the main source of woody biomass and the roles of forest management and forest industries are determinant to wood energy, but the forestry sector alone cannot resolve the wood energy puzzle. Successful planning requires a thorough understanding of the entire context, which encompasses the whole supply chain, including non-forest supply sources, the consumption patterns and trends, and its social, economic and institutional stakeholders.

Woodfuels Integrated Supply / Demand Overview Mapping (WISDOM)

Wood energy systems, intended as the sequence of actions and elements that comprise the production, distribution and consumption of woodfuels, are complex and site specific. They may, or may not, involve trade aspects; similarly, and to some extent consequently, woodfuels may be transported far from their production sites, or they may be gathered and consumed locally; consumption patterns may change rapidly in favour of "higher" fuels such as gas and kerosene, or "lower" fuels such as agricultural residues or cow dung, in response to varying market conditions or levels of accessibility to wood resources.

In order to cope with the various dimensions of wood energy systems, the Wood Energy Programme of FAO developed and implemented the Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) methodology, a spatially-explicit planning tool for highlighting and determining woodfuel priority areas or woodfuel hot spots (Drigo et al., 2002; FAO, 2003). In its first formulation, WISDOM is the fruit of collaboration between FAO's Wood Energy Programme and the Institute of Ecology of the National University of Mexico. At national level, the WISDOM approach has been implemented in Mexico (FAO, 2005; Masera et al., 2006), Slovenia (FAO, 2006a), and Senegal (FAO, 2004). At subregional level, WISDOM was implemented over the eastern and central Africa countries covered by the Africover Programme[2] (FAO, 2006b) and over the countries of SE Asia[3] (FAO, 2007). While writing, the methodology is being implemented in Argentina and sub-national studies were just completed for Castilla y Leòn in Spain and Emilia Romagna in Italy.

The WISDOM methodology is characterized by its thematic specificity (woodfuels rather than generic energy or forestry planning) and by its open framework (it's not a package), which allows a high degree of flexibility and adaptability in the heterogeneity and fragmentation of the data related to the production and consumption of woodfuels. WISDOM approach has the advantage of considering the entire demand and supply context, which supports a consistent and objective definition of the sustainable supply zones of the major cities (Urban Woodsheds).

A national-level WISDOM analysis does not replace detailed local-level analyses for operational planning, but rather it is oriented to support a higher level of planning, i.e. strategic planning and policy formulation, through the integration and analysis of existing demand and supply-related information and indicators. More than absolute and quantitative data, WISDOM is meant to provide relative or qualitative valuations, such as risk zoning or criticality ranking, highlighting, at the highest possible spatial detail, the areas deserving urgent attention and, if needed, additional data collection. In other words, WISDOM should serve as an assessing and strategic planning tool to identify sites for priority action.

WISDOM is based on: a) the use of geo-referenced socio-demographic and natural resource databases integrated within a geographical information system; b) a minimum spatial unit of analysis at sub-national level; c) a modular, open, and adaptable framework which integrates information of relevance to wood energy from multiple sources; and d) a comprehensive coverage of woodfuel resources and demand.

2. Main features of WISDOM Mozambique

Overview of the methodology

An overview of the analytical steps and main thematic layers of WISDOM Mozambique is shown in Figure 1.

In consideration of the acquisition dates the satellite images used for the interpretation of land cover and the

[2] Burundi, DR Congo, Egypt, Eritrea, Kenya, Rwanda, Somalia, Sudan, Tanzania and Uganda.

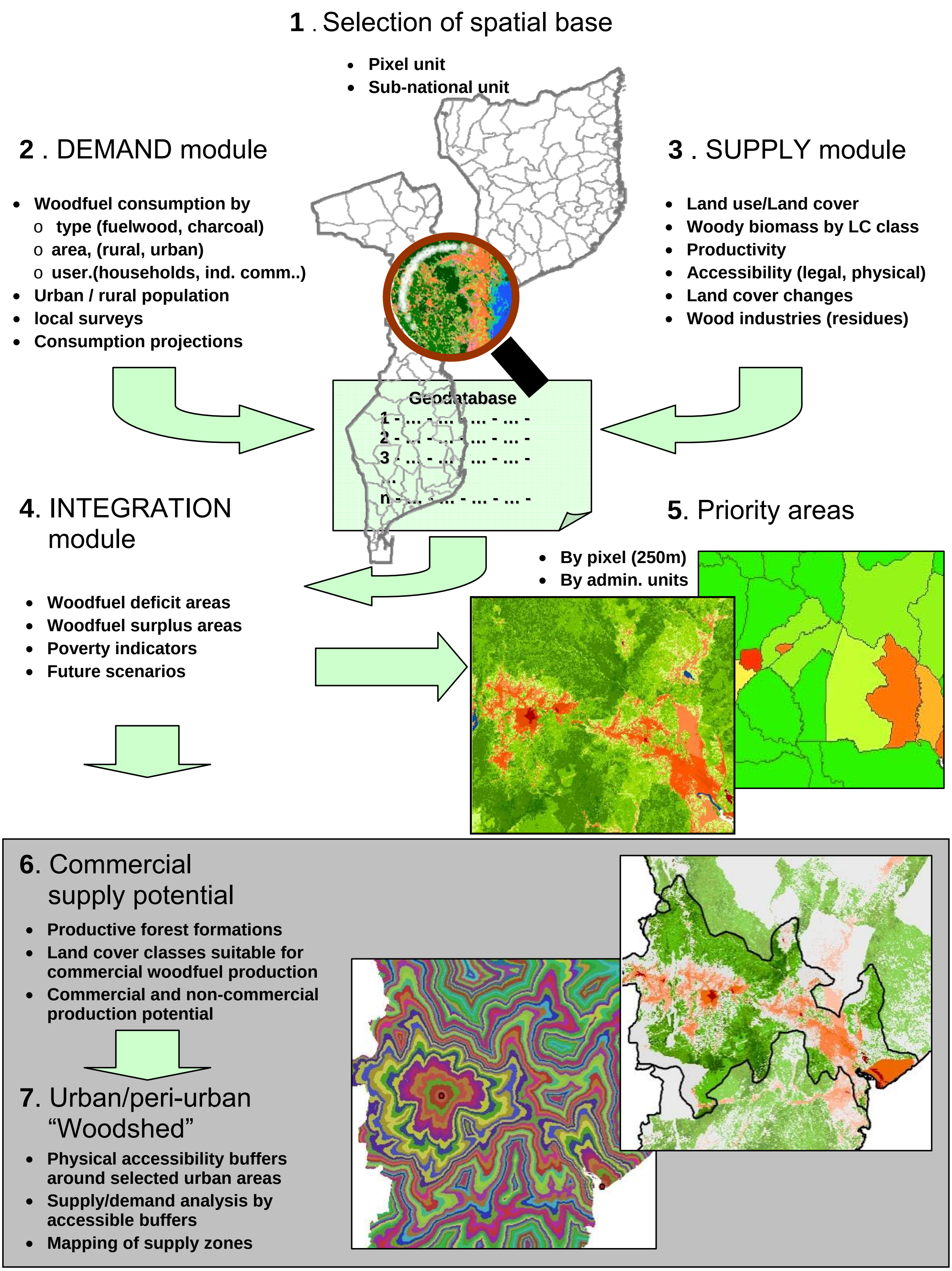
[3] Cambodia, Malaysia, Laos, Thailand, Vietnam and the Yunnan Province of China.

stratification of the national forest inventory, it was agreed to set the reference year of the WISDOM analysis at year 2004.

The procedure of analysis and main considerations on the data available for Mozambique are discussed in the following Section on “Data, estimation procedures and main results”.

The main variables, actions for procurement and processing are listed Annex 1: “Summary of main layers, variable and data sources of WISDOM modules”

Figure 1: WISDOM Mozambique. Main analytical steps and thematic layers



3. Data, estimation procedures and main results

3.1 Selection of spatial base

Cartographic administrative base of analysis

The administrative maps used in the study are those provided by INE, referring to the Census of 1997. The map presenting the highest geographic detail, that of Postos Administrativos (PA), was selected as main reference. The District and Province layers were derived from PADM map according to the hierarchical administrative map attributes into:

- Provinces
- Districts
- Postos administrativos

Future updates of the WISDOM geodatabase will include the new and more detailed administrative maps that refer to the Census 2007. On such basis it is expected to achieve the layers of Localidades and of Aldeias, which will allow, for instance, a finer distribution of rural population.

Other layers

Land Cover. The land cover map used as main reference was the National Land Cover of Mozambique, which was created in the framework of the AIFM Programme and used as basis for the National Forest Inventory design. This map was used in various processes, including the mapping of biomass stock and increment, the mapping of physical accessibility and the rural population probability model. The map and legend in Figure 2 shows a "summary" of the map by displaying the principal land cover class (in the full resolution map each map unit may include mixtures of up to three classes in varying proportions).

Tree Cover Percent map based on MODIS 500m (Hansen et al. 2003), resampled at 250m.

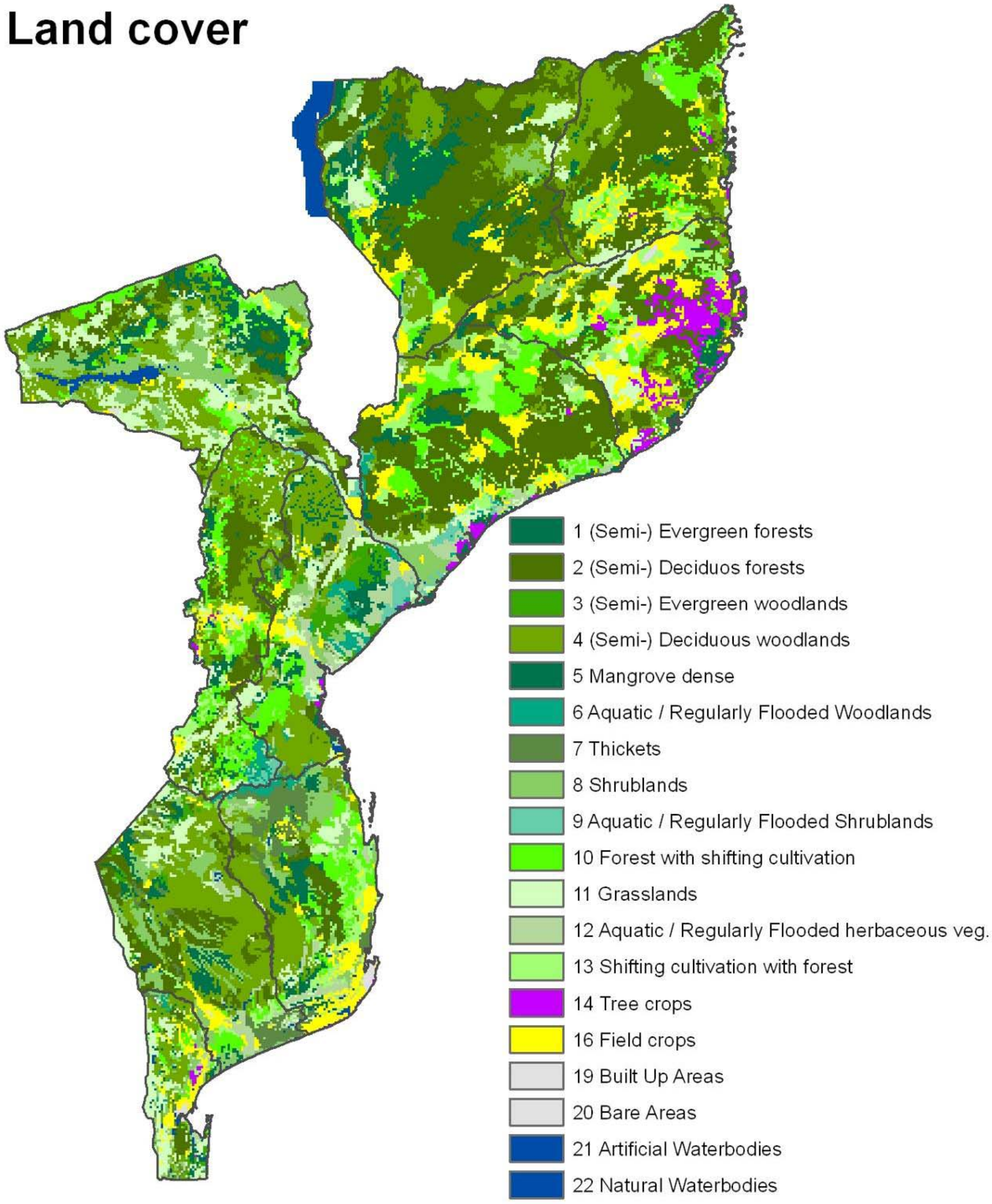
Urban areas. The map of urban areas used in the analysis was in large part created purposely for the WISDOM analysis as the existing data appeared grossly incomplete. The update of the map was done through the interpretation of remote sensing data (via Google Earth, mainly) and delineation of the 23 Cidades and 68 Vilas identified by INE as the urban areas of Mozambique.

Road network. The available maps of communication infrastructure are rather poor and limited to major motorable roads.

Raster analysis

Raster base. Considering the scale and spatial resolution of the land cover map, of the population distribution parameters and spatial proxies and other factors it was decided to adopt a raster cell size of 250m.

Figure 2: Land Cover Map of Mozambique



3.2 Demand module

The flowchart in Figure 3 provide a simplified description of the main thematic layers and processing steps required to complete the Demand Module.

3.2.1 Consumption in the residential sector

The most recent and detailed reference on fuelwood and charcoal consumption in the rural and urban areas of Mozambique (Sitoe, UEM, 2007 Pers. comm.) based its estimates on direct and indirect measurements taken in six Provinces: Tete, Nampula, Zambézia, Sofala, Gaza and Maputo/Matola (concentrating the survey in two Districts in each province). The indirect approach was based on available statistics on production, transport and commercialization of woodfuels from Serviços Provinciais de Florestas e Fauna Bravia. The direct method was based on measurement of household woodfuel consumption in a representative sample (564 charcoal-consumer and 169 fuelwood-consumer households in urban areas; 576 households in rural areas of the selected provinces).

The results show a considerable variance in the rural consumption levels for the provinces of Sofala (309 kg/person/year) and Zambézia (1095 kg/person/year) and more uniform values for the other provinces, ranging between 600 and 800 kg/person/year. Not being able to explain the variance among estimated provincial values it was decided to use an average percapita annual consumption (weighted on sample number) of 695 kg of air dry wood (612.5 kg oven dry or 0.96 m^3) to be applied uniformly over the entire country.

The same survey indicates an average annual consumption by urban dwellers (limited to woodfuel users) of 1.36 air dry t of wood (1.2 oven dry t or 1.87 m^3) which, expanded to the entire urban population would give an average per capita ranging between 0.7 and 1 air dry t (0.61-0.88 oven dry or 0.96-1.37 m^3), assuming a saturation of 0.512 and 0.733, respectively (see Tables 1 and 2 below).

The survey in Marracuene (Mirasse and Brouwer, 2004) pro vides some additional data. The average per capita consumption estimated in this study, i.e. 0.72 m3 /person /year , is probably lower than the actual consumption value (as declared by the authors , page 50) as the study considered only the purchased fuels and excluded the "informal" sources.

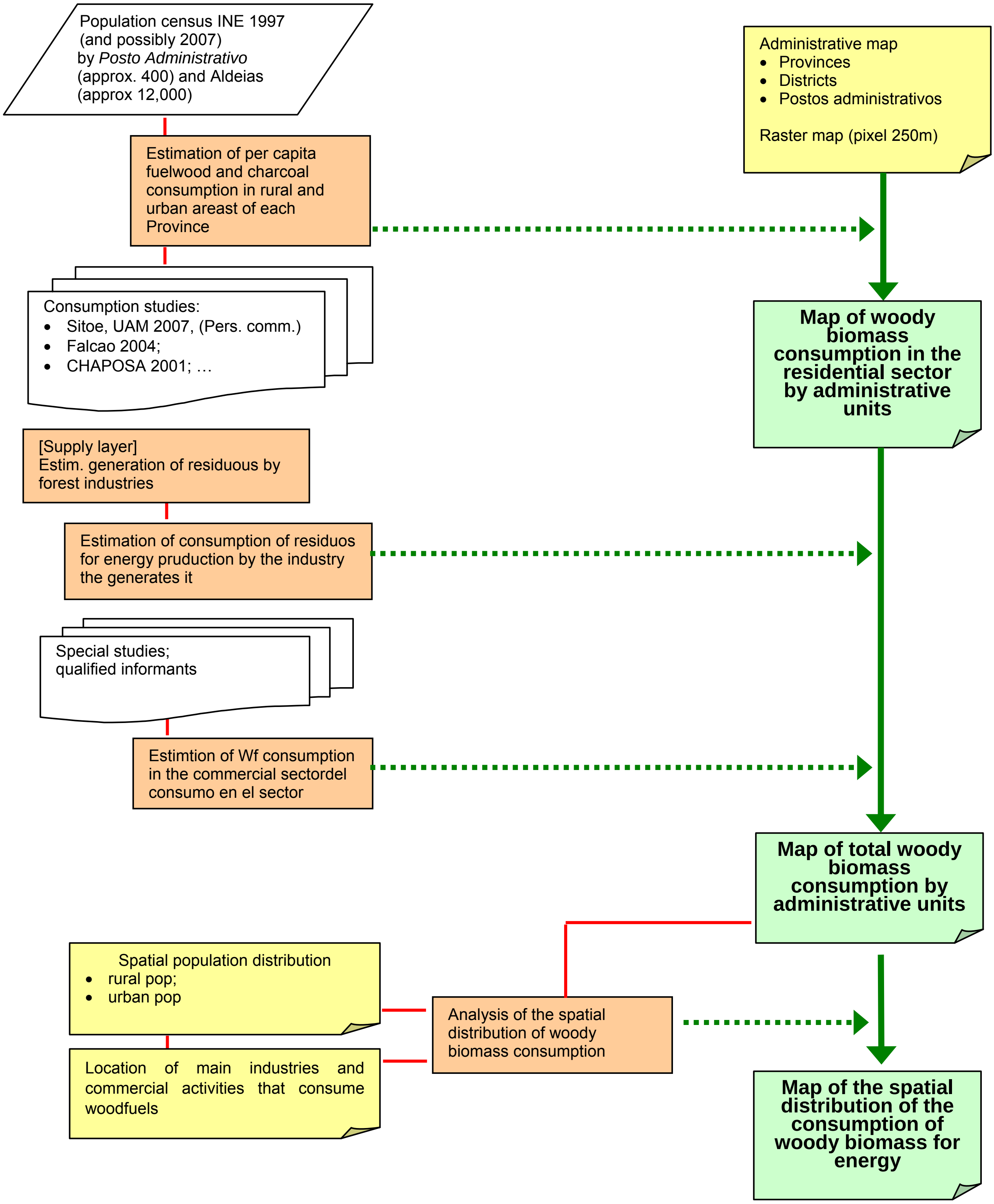
Limited to the consumption in the City of Maputo, the study carried out in the framework of the CHAPOSA Project (Brower and Falcao, 2001) provides estimates of the per capita wood consumption (fuelwood and wood for charcoal) of urban inhabitants (user and non-users of woodfuel) between 0.92 and 1 m3 per year, which corresponds to some 0.67 - 0.73 air dry or 0.55 – 0.59 oven dry t of wood.

3.2.2 Saturation of woodfuel use

Estimates on the fraction of urban and rural population that uses fuelwood and or charcoal for cooking and for lighting can be taken from INE's surveys of households (IAF 2002/3) and from INE's survey of basic well-being indicators (QUIBB 2000/1). The problem is that these two references provide significantly different results. The QUIBB 2000/1 survey says that the fraction of urban population using fuelwood/charcoal was 85.6%, overall, and gives values of 51.2 and 76.3 for Maputo City and Maputo Province, respectively. The household survey IAF 2002/3 says that the overall fraction in urban areas was 92.8 and 73.3 and 87.2 for Maputo City and Maputo Province, respectively. The two studies refer to slightly different urban/rural proportions, with IAF 2002/3 indicating 29.8% urban vs. the 27% of QUIBB 2000/1. This could well represent an urbanization trend but does not entirely explain the difference in consumption patterns.

The difference appears too big to be a true change in consumption habits and it's difficult to select the most reliable set of values. The QUIBB 2000/1 survey is two years older but was based on 13,790 interviews, as compared to the 8,727 of the IAF 2002/3 survey. Consequently, since there is no reason to think that the true values is outside the interval defined by the two surveys, it was assumed that the likely saturation in Maputo Capital be somewhere in the middle and the two survey values were taken as lower and upper limit of the likely range (Table 1).

Figure 3: WISDOM Mozambique: Demand Module. Flowchart of main analytical steps



On this basis, and considering the most reliable consumption values discussed above, the minimum, medium and maximum per capita consumption values were determined for rural and urban dwellers. In order to reflect the transition between rural and urban consumption patterns, the consumption pattern in the smaller towns (vilas) was assumed as intermediate between the major cities (cidades) and rural areas. The consumption values applied to population data to estimate and distribute woodfuel consumption throughout the country are presented in Table2.

Table1: Estimated saturation of woodfuels in the residential sector (percent of total population that uses primarily fuelwood and/or charcoal for cooking and for other household services)

	Rural saturation	Cidade saturation	Vila saturation	
max	100	**73.3**	86.65	Ref: IAF2002/3, INE, for Maputo Capital
med	100	62.3	81.1	Average of the two INE sources
min	100	**51.2**	75.6	Ref: QUIBB 2000/1, INE, for Maputo Capital

	Fraction of total provincial population			Saturation estimated		
	RuralPop	Cidades	Vilas	**Min**	**Med**	**Max**
Cabo Delgado	0.8315	0.1097	0.0587	**93.2**	**94.7**	**96.3**
Gaza	0.7495	0.1879	0.0626	**89.3**	**91.7**	**94.1**
Inhambane	0.8037	0.1304	0.0659	**92.0**	**93.8**	**95.6**
Manica	0.7186	0.2047	0.0767	**88.1**	**90.8**	**93.5**
Maputo	0.3725	0.5268	0.1007	**71.8**	**78.2**	**84.6**
Maputo Capital	0.0000	1.0000	0.0000	**51.2**	**62.3**	**73.3**
Nampula	0.7406	0.1984	0.0610	**88.8**	**91.4**	**93.9**
Niassa	0.7695	0.1890	0.0414	**89.8**	**92.1**	**94.4**
Sofala	0.5827	0.3609	0.0564	**81.0**	**85.3**	**89.6**
Tete	0.8532	0.0890	0.0578	**94.2**	**95.6**	**96.9**
Zambézia	0.8417	0.1287	0.0295	**93.0**	**94.6**	**96.2**
Mozambique	0.7016	0.2455	0.0529	**86.7**	**89.7**	**92.7**

Table2: Estimated per capita woodfuel consumption levels.

	Average per capita residential consumption of users only		
	Rural areas	Urban areas	
(air dry kg*pers^{-1}*year^{-1})		Vilas	Cidades
Minimum	630.1	994.4	1358.7
Medium	695.3	1027.0	1358.7
Maximum	760.4	1059.6	1358.7
	Estimated saturation of residential woodfuel users		
	Rural areas	Urban areas	
(% of total population)		Vilas	Cidades
Minimum	100.0	75.6	51.2
Medium	100.0	81.1	62.3
Maximum	100.0	86.7	73.3
	Average per capita residential consumption (users and non-users)		
	Rural areas	Urban areas	
(air dry kg*pers-1*year-1)		Vilas	Cidades
Minimum	**630.1**	**751.8**	**695.7**
Medium	**695.3**	**833.2**	**845.8**
Maximum	**760.4**	**918.1**	**996.0**
	Average per capita commercial consumption (users and non-users)		
	Rural areas	Urban areas	
		Vilas	Cidades
(air dry kg*pers-1*year-1)			84.6
% of residential consumption		10.0	10.0
	Average per capita residential and commercial consumption		
	Rural areas	Urban areas	
(air dry kg*pers-1*year-1)		Vilas	Cidades
Minimum	**630.1**	**827.0**	**765.3**
Medium	**695.3**	**916.5**	**930.4**
Maximum	**760.4**	**1010.0**	**1095.6**

3.2.3 Consumption in the commercial sector

The woodfuel consumption study carried out in the framework of the CHAPOSA Project (Brower and Falcao, 2001) over Maputo provides some insight on the consumption levels and patterns of the commercial sector. Estimates are provided for bakeries, food stalls (*barracas*), restaurants and hotels. According to this study, the consumption of charcoal (mainly in food stalls, restaurants and hotels) and that of fuelwood (mainly in bakeries and industries) in the city of Maputo in 2000 added up to some 86.3 thousand t of wood_equivalent, which corresponds to a per capita consumption of 84.6 kg, or 10% of the amount used in the residential sector. This estimate should be considered as indicative only since the “explorative” survey had a limited intensity and covered Maputo City only. Nevertheless, in absence of more accurate estimates, the 10% value was used to estimate and distribute the commercial consumption in the urban areas (i.e. cidades and vilas) of the Country, as shown in Table 2 above. The percent value was kept constant in cidades and vilas considering that in the smaller towns it’s likely that the per-capita number of commercial enterprises be lower than in Maputo but it’s also likely that the fraction of used fuelwood and charcoal in respect to other fuels be higher and thus these factor are likely to compensate each other.

3.2.4 Spatial distribution of woodfuel consumption in residential and commercial sectors

Spatial distribution of rural population.

- Aldeias The procedure of rural population distribution based on “aldeias” was considered at length but finally rejected because the coordinates of the aldeia points proved extremely inaccurate, with a high proportion of points falling outside the district defined by their own codes. The coordinates problem needs complete revision before the aldeias layer can be used in a GIS context.
- Posto administrativo (PA). Failing at aldeias level, the procedure of spatial distribution of rural population was based on the 383 polygons reporting rural population data (other PA are classed as urban only). Even the PA approach presented some problems because for several PA units only urban population statistics were available, though it’s evident that there are areas outside the urban settlements where the population is definitely rural. In these cases the rural/urban distinction was inferred by assuming an average rural population density in the PA portions outside actual city areas based on the rural densities of surrounding PAs and deducting this “assumed” rural population from the urban population given by INE statistics for that PA.
- The spatial distribution algorithm of rural population (defined by PA statistics) was based on land cover characteristics, road proximity and river proximity and terrain model. In order to evaluate the significance of certain variables (i.e. the influence of river proximity on patterns of population distribution) factorial analysis was carried out over the Province of Manica as well as over the entire country using PA population as function of relevant land features (land cover classes, proximity from roads and other populated places) (Lorenzini 2008). Weights and ranking of land cover and road proximity in respect of rural population distribution as “suggested” by the factorial analysis are also shown in Annex 5.

Spatial distribution of urban population.

- **Cidades** (23) based on INE for the statistical data and on AIFM for digital delineation, which was done using GoogleEearth images and with the following interpretation criteria:
    - <u>City centers</u>: built up, industrial, infrastructure, farming < 10%;
    - <u>Urbanized periphery</u>: residential and farming, with farming 10-70% (if farming > 70% = rural)
- **Vilas** (68) based on INE for the statistical data and on AIFM for digital delineation (following the same interpretation categories used for the cidades).

Population statistics to be spatially distributed referred to the situation at year 2004, which is the reference date of WISDOM analysis. The reference demographic statistics that can be used to assess 2004 urban and rural populations are:

- INE 1997
- Projection to 2004 based on INE 1997 and successive projections revisions

- Preliminary District-level results of the INE Census 2007 (limited to total population, without systematic urban/rural distinction but with separate statistics for the provincial capitals and for few other major cities)

The best approach to estimate 2004 population appeared to be using 1997 – 2007 total population growth rates by district with inference of urban/rural fractions based on the growth rates of the cities reported in the 2007 Census results.

Missing any reference data on fuelwood and charcoal consumption in commercial activities in all urban areas of the country, it was assumed, tentatively, that the same proportion to residential consumption found for Maputo (for which some estimates existed in Brower and Falcao, 2001) applied also to other cities. On this basis and using the Maputo study as reference, the consumption of charcoal and fuelwood in bakeries, restaurants, barracas, etc. in the cidades and vilas was quantified as 10% of the residential consumption.

The map of the spatial distribution of woodfuel consumption in the residential and commercial sectors is shown in Figure 4.

3.2.5 Consumption in the industrial and agricultural sectors

Reference studies on the consumption in the industrial sector could not be found, so far. For this, it's important to continue the literature search for national and international references (privileging countries of the sub region in similar conditions). As indicative reference, Annex 3 reports a list of activities, branches and sectors of woodfuel end use prepared by FAO (2002.)

Consumption of wood residues for energy production by the forest industries will be estimated on the basis of interviews to be conducted with qualified informats such, as, for instance, the managers of the most representative forest industries in Maputo, Sofala, Zambézia, Cabo Delgado.

Other main industrial processes known to use woodfuel as energy source in Mozambique include: The (chá) drying; tobacco drying; fish smoking; ceramics; brick making; blacksmith. Statistics on the location and production levels of these industries must be gathered in order to estimate, at least tentatively, how much woody biomass is used in their productive processes and where.

To date, only limited information on the use of fuelwood for tobacco drying could be obtained (RuralConsult Lda, 2006). According to available sources, the consumption of fuelwood for tobacco drying in Mozambique is about 25 m^3 for each hectare cultivated. Other authoritative sources indicate some 40m^3 per t of dried tobacco. Geist (1999) indicates the world's average at 20 m^3 . With reference to the estimations made for Mozambique, the mean value of fuelwood consumption per hectare of tobacco was set at 22.8 t, with lower and upper values of 18.1 and 27.5, respectively.

Table 3: Estimated fuelwood consumed in the Provinces to dry local tobacco production (t of woody biomass)

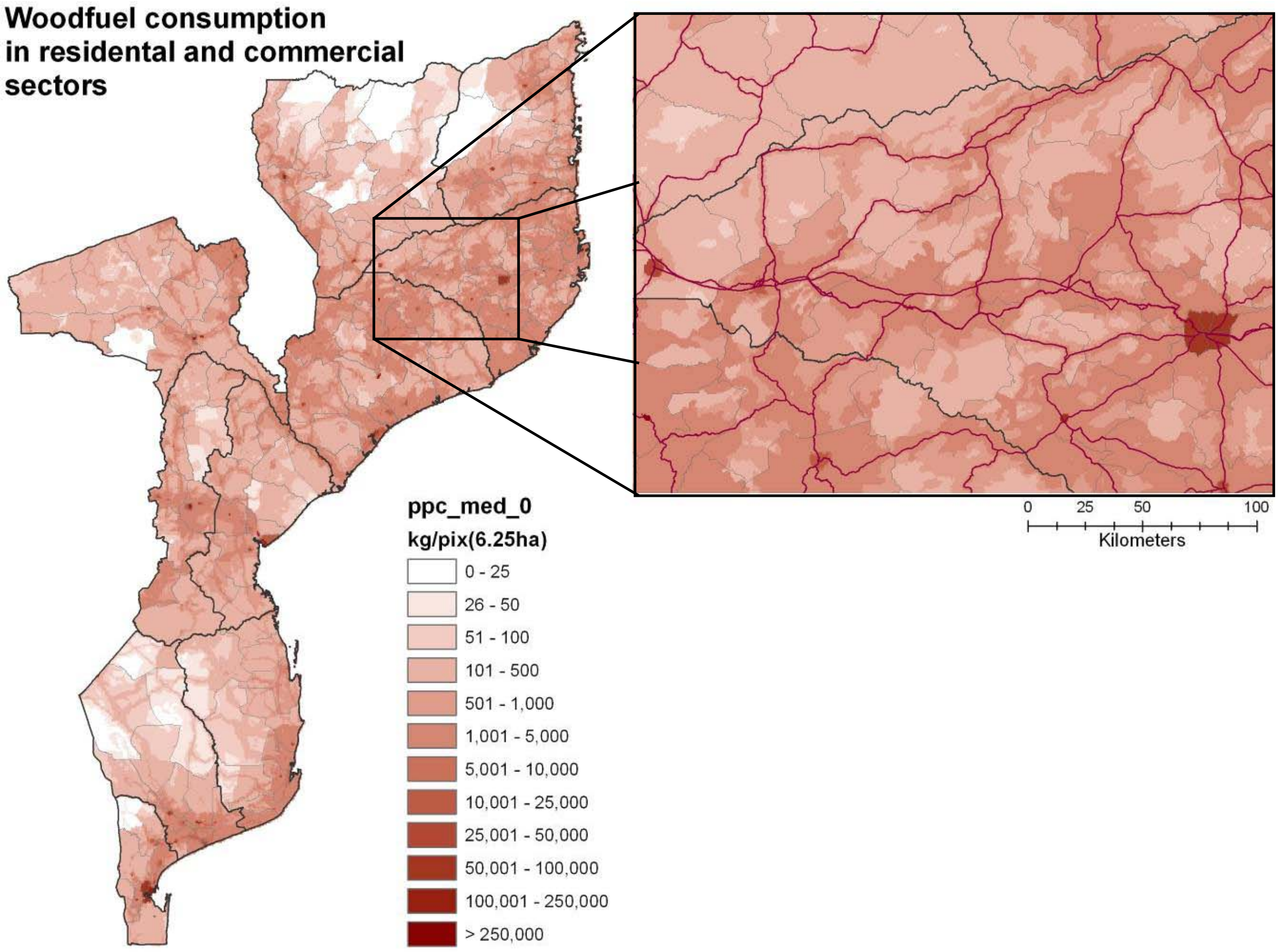
	Niassa	CD	Namp.	Zamb	Tete	Manica	Sofala	Inhab.	Gaza	Maputo	Tot
min	457,693	8,319	121,166	55,952	789,978	107,010	3,371	163	109	1,088	1,544,848
med	**576,137**	**10,472**	**152,522**	**70,431**	**994,413**	**134,703**	**4,244**	**205**	**137**	**1,369**	1,944,633
max	694,581	12,625	183,878	84,911	1,198,849	162,395	5,116	248	165	1,650	2,344,418

3.2.6 Spatial distribution of industrial woodfuel consumption

The estimation and mapping of industrial woodfuel consumption was the weakest component of the entire study due to total absence of information.

Although it appears that the consumption in the industries is rather limited it is recommended to proceed with the identification of the industrial processes that use fuelwood and/or charcoal and to attempt quantitative estimates and mapping.

Figure 4: Spatial representation of woodfuel consumption in Mozambique



3.3 Supply module

The flowchart in Figure 5 provides a simplified description of the main thematic layers and processing steps required to complete the Supply Module.

3.3.1 Direct supply sources (land covers / land uses)

Direct supply sources refer to the land cover classes and relevant stock and productivities.

Main source data used in the estimation process were:

- National forest inventory data.
- Land cover/ecological class groupings.
- Biomass expansion factors, wood density factors and chosen increment estimation equations.
- Stock and sustainable productivity of surveyed land cover classes. The estimation of (minimum, medium and maximum) biomass stock per hectare and productivity was done considering the individual land cover classes, the ecological regions where they occur (considering only meaningful land cover-region combinations) and the class combinations (primary, secondary and tertiary, with relevant internal proportions) that are actually represented in the final land cover map[4]. This resulted in 2277 individual "biounits" (intended as multi-polygon entities) each of which carrying a certain biomass stock (t/ha) value.
    - o The spatial distribution of woody biomass stock and sustainable biomass productivity was done using the MODIS Tree Cover Percent[5] values as proxy of spatialization to represent the stock and productivity variance within the entire "biounit" category, according to the following formulation:

$$\textit{value in cell}_i \textit{ of biounit}_b = \textit{tree cover}_i / \textit{average tree cover of biounit}_b * \textit{average value of } b_b$$

Example of biounits, Modis tree cover data and resulting stock map are shown in figure 6.

- Deduction of industrial assortments (referred to as potential industrial productivity and not only actual current extraction). On long term planning, the amount available for energy use is limited to the non industrial assortments, including the branches and defective stems of the commercial species. For a shorter term planning it should be considered that the non-commercial fraction of commercial trees is not really available until the commercial assortment is actually extracted. In this respect the statistics of extracted industrial volumes may be used to improve the estimation of currently available woody biomass.
- Deduction of non-industrial assortments used for uses other than energy, such as construction poles and fraction of trees/shrubs that provide non-wood forest product and that are thus protected by villagers. The construction poles fraction was estimated on the basis of the average amount of wood used in the building of rural hats, the average duration of the construction and the average number of inhabitants, parameters derived from a research conducted in the Province of Inhambane (Cuambe, 2004). It was thus estimated that the average annual demand of poles for construction purposes for each individual rural dweller is approximately 0.024 m^3 , or 18 kg of air dry woody biomass. Thereafter, the poles volume demand was distributed as a direct factor of the map of spatial distribution of the rural population (where the constructions are located) and then deducted from the non-industrial productivity mapped during the previous step.
- Stock and sustainable productivity of NON-surveyed land cover classes.
    - o Spatial distribution (MODIS Tree cover values as proxy)
- Supply scenarios and projection based on land cover change rates (Manica, entire country).

---

[4] For a complete description of the procedure followed for the estimation of biomass stock and increment, its non-industrial share etc., reference is made to the report of the Biomass Inventory Expert, Marzoli (2008).

[5] Tree Cover Percent map based on MODIS 500m (Hansen et al. 2003), resampled at 250m.

Figure 5: WISDOM Mozambique: Supply Module. Flowchart of main analytical steps

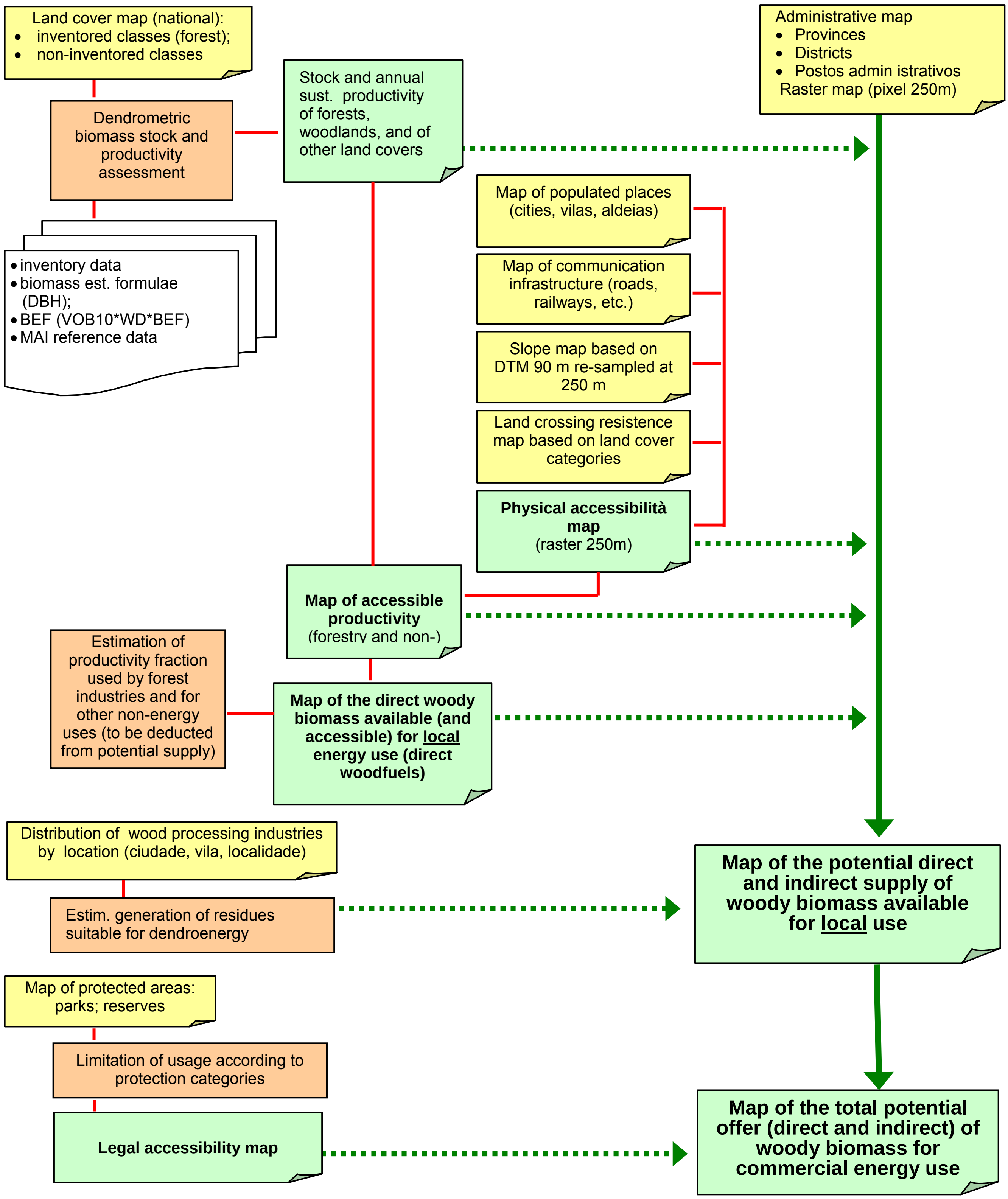
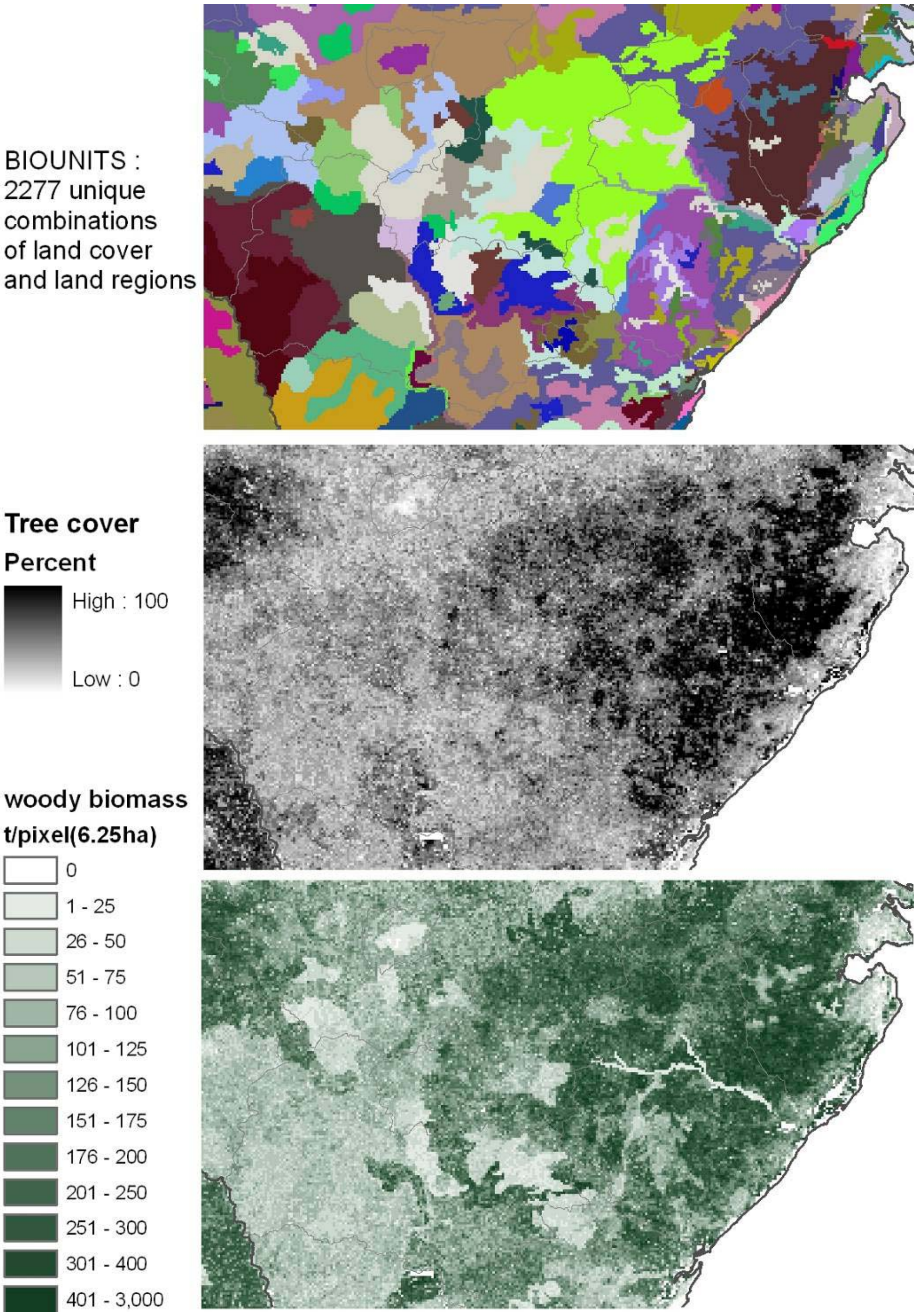


Figure 6: Cartographic "ingredients" of the supply module (Biounits based on land cover and ecological zones; Tree Cover Percent map based on MODIS 500m) and woody biomass stock map.



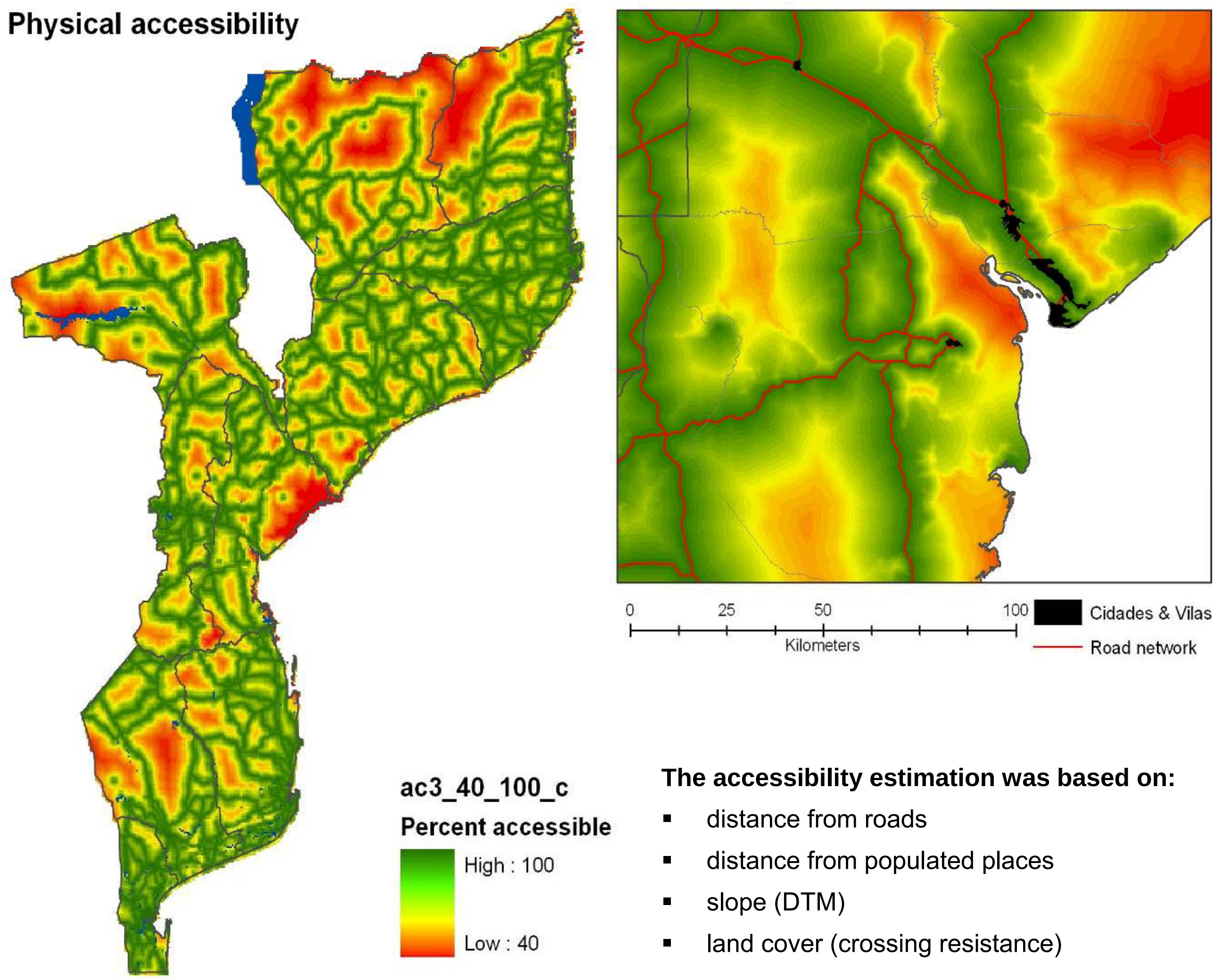
3.3.1.1 Accessibility

Physical accessibility

This is the spatial parameter that defines the accessibility of a given biomass resource in relation to the distance of the nearest road and populated place and to a "cost" factor based on the slope and on the characteristics of the terrain to be crossed. The definition of the "resistance" created by slope and terrain characteristics used in the cost-distance analysis is shown in Annex 5.

The continuous value resulting from the cost-distance analysis was then converted into segments on quantiles and an accessibility factor (% accessible) was associated to each segment. Considering that the available road map is incomplete since it does not report smaller tracts and that the location of rural villages below the "vilas" level are also not known, the influence of the cost-distance analysis was not overemphasized in the accessibility ranking. In fact, the highest cost areas were not considered as totally inaccessible but only partially accessible. Quantitatively, it was set that to the highest cost areas was given a factor of 0.4 (40 % of the resources being considered physically accessible) and that such factor was progressively increase to reach 1 in the lowest cost zone (100% of resources accessible). The map of physical accessibility resulting from the process is shown in Figure 7.

Figure 7: Physical accessibility map.



Legal accessibility

Accessibility restrictions to forest exploitation within protected areas are limited to commercial operations, leaving virtually untouched the rights of local populations to gather the fuelwood and construction material needed for own use. This means that legal accessibility was here used only in the definition of the "commercial" productivity, while it was not considered in the calculation of the local supply/demand balance. In practice, the legal accessibility factor was applied only to the surplus biomass resulting from local balance, and thus reducing the resource available for commercial charcoal and fuelwood production for distant urban markets and exports.

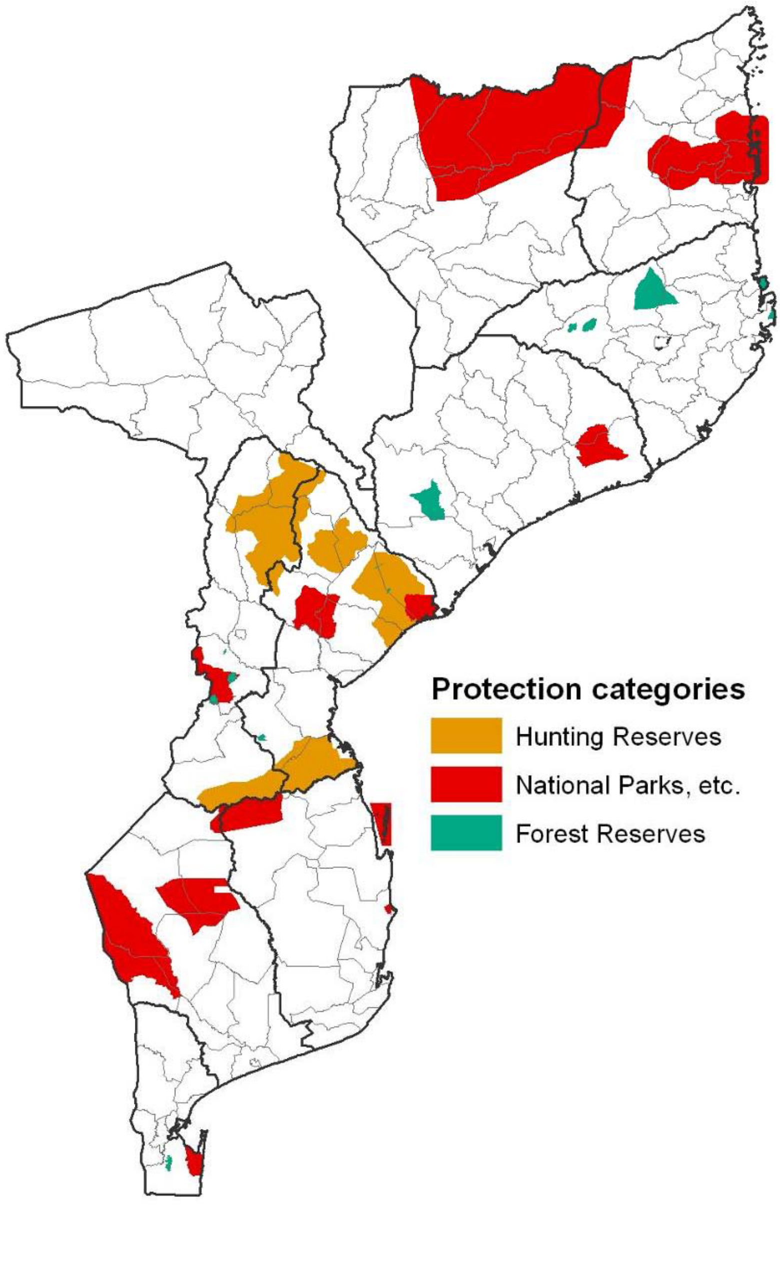
Main protection categories:

- Protected areas under Min. Of Tourism.
- Hunting Reserves
- Reservas Florestais

  The protected areas under the above three categories are shown in Figure 8.

- Fazendas de Bravio. A list of the Fazendas do Bravio currently in operation and under designation process is given in Annex 4. This dataset is only partially digitized and the inclusion in the analysis of accessible resources is therefore incomplete.

Figure 8: Protected areas categories used to map legal accessibility constraints. (Fazendas do Bravio are not displayed due to incomplete data)



3.3.2 Indirect supply sources

Residues of forest industries

The procedure to create a geostatistical database of forest industries' residues potentially available for energy uses involved two main steps, the first aiming to the geographic distribution of the industries (and of the relevant amount of row material used and/or final products) and the second one to assess residue generation according to the industrial processes and material used and/or produced:

1. Harmonization of the 3 main databases reporting the names, locations, concession areas (for the industries that have concessions) and other forest industries' details:

   - DNTF database of forest industries with felling concessions (approx 190 units including some for which the concession has been cancelled). List updated in 2007.
   - National survey of wood-processing industries (with or without concessions) reporting survey results 1997,8,9 and projections 2000,1,2,3 (Eureka Lda 2001)
   - Survey of forest industries (with or without concessions) Sofala, Zambézia and Cabo Delgado. Survey conducted in 2006, with data up to 2005 (Rural Consul, 2006a)

   The last two databases provided some statistics on the type of industry (with or without concession, sawmills, carpentry, etc.), row material utilized (toros) and/or on processed products. The resulting database was then set in relation with provincial wood products statistics for year 2004 in order to distribute the total provincial amounts, that appeared more consistent, according to local industries' parameters.

   Although all database presented missing values and inconsistencies, a location was determined on the basis of the addresses and other location details (cidade, vila, PA or District).

2. Estimate residues production on the basis of existing national and international references. In this first assessment, the residues production was estimated as 50% of the raw material processed, considering sawmill residues and the subsequent residues produces in the following processing phases. It's recommended to further pursue this item in collaboration with the Department of Forest Engineering of the University Eduardo Mondlane.

Recovered wood

It was impossible to assess the amount of recovered wood , such as dismissed construction material, furniture, pallets etc. because there are no formal or even slightly related statistics. For instance, there is no pallet factory in the country from which some product lifecycle information could be obtained. Some additional investigation is recommended but it is unlikely that this component becomes significant in the woody biomass supply demand scenario.

3.3.3 Overview of supply potential

The various categories of biomass productivity that constitute the woody biomass potentially available for bioenergy from direct and indirect sources may be summarized as follows:

Total productivity: This defines the biological sustainable capacity to produce woody biomass in current land cover/land use conditions. It does not include leaves, twigs and roots but includes all species, and vegetation formations and land cover/uses. This category is mainly theoretical as it includes inaccessible resources as well as products that pertain to other uses and/or industrial processes.

Non-industrial productivity: This category refers to the fraction of total productivity that has no industrial interest in terms of species and assortments and that is not used for other purposes. From this productivity are excluded the stems of the precious species of quality 1, 2 and 3, as clearly indicated by the national regulations that rule forest exploitation in Mozambique (Art. 19, LFFB). In addition to the woody biomass from other non-precious species, the non-industrial biomass productivity does include the branches as well as the defective stems of the precious species since they have no use in wood industries. The industrial wood is deducted, as a fraction, only from the forest land cover classes defined by the National Forest Inventory.

Physically accessible non-industrial productivity: This category defines the fraction of the total non-industrial biomass productivity that may be considered accessible, after deduction of the areas and fractions of productivity that are inaccessible due to physical constraints (i.e., slope, distance from roads and populated places, crossing resistance of land cover classes).

Available productivity: This category defines the fraction of the accessible non-industrial productivity that remain available for energy uses after deduction of the woody biomass annually consumed for other purposes. This implies the estimation, and exclusion, of the material used as construction material by rural dwellers as well as that used for tobacco drying. The construction poles' biomass is not deducted from the productivity map directly but rather mapped as an additional demand component associated to the rural population map (a sort of "biomass debt").

This is the supply resources considered for the estimation of local supply/demand balance.

"Commercial" productivity: This category does not refer to the productivity per se but rather defines the fraction of the surplus, determined by the local supply/demand balance and hence after satisfaction of local demands, which may be suitable to sustain commercial fuelwood and charcoal production to feed urban markets and export (see detailed description under "Commercial balance" in the following section). It is limited to the formations that guarantee an adequate sustainable production of wood for energy that justify transport and management costs. The sources included are those with higher sustainable production capacities and that are free from legal restrictions that allow for local non-commercial exploitation only (i.e., national parks, other protected areas, *fazendas do bravio*, reserved forests, hunting reserves, etc. …). This category refers to the fraction of the surplus resulting from local supply/demand balance analysis that may be considered as available and suitable for commercial bioenergy planning.

Province-level summary WISDOM statistics reporting also stock and available productivity data are given in Table 5 further below. The same statistics summarized at District level are presented in Annex 8.

Figure 9: Supply potentially available for energy use from direct and indirect sources.

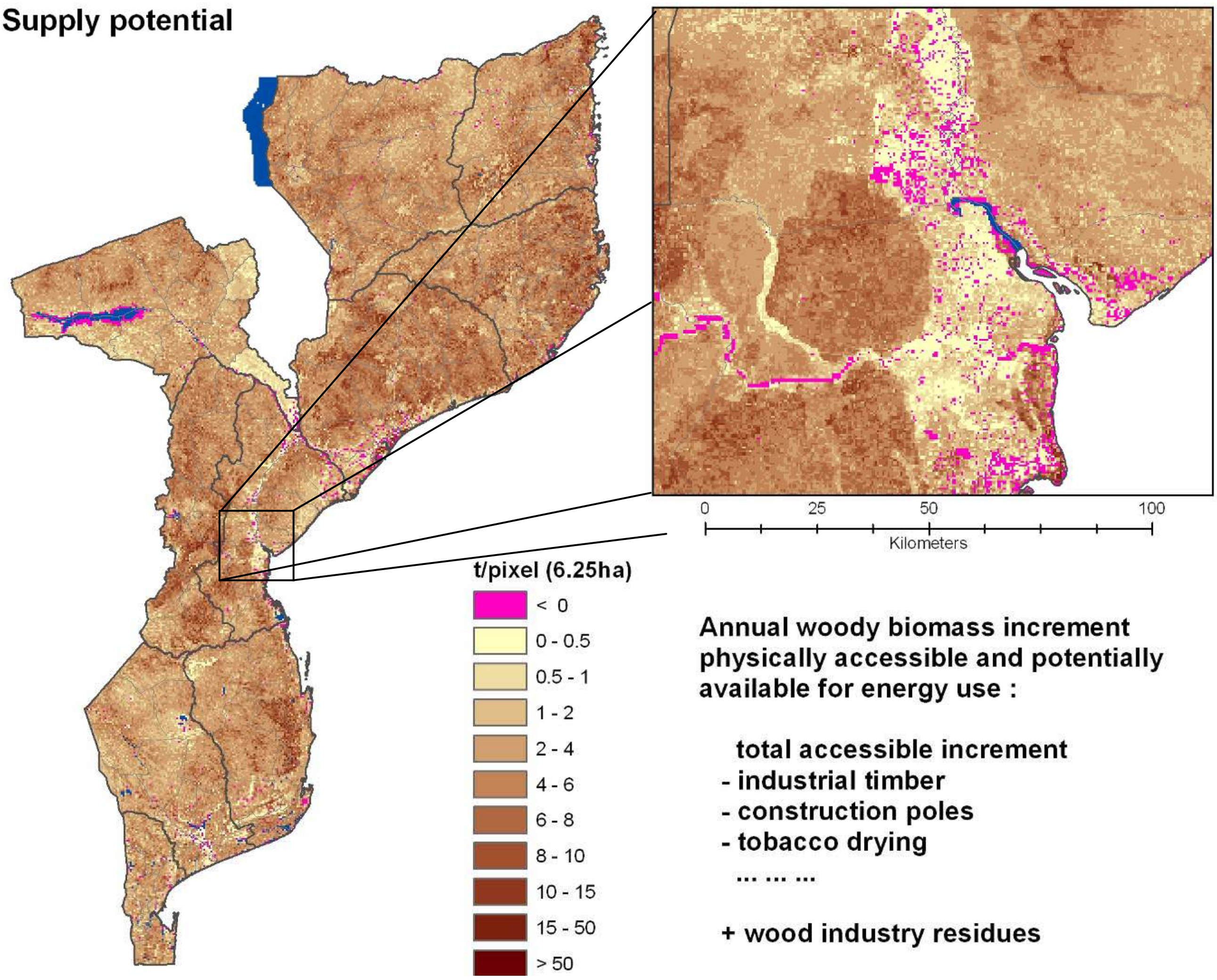
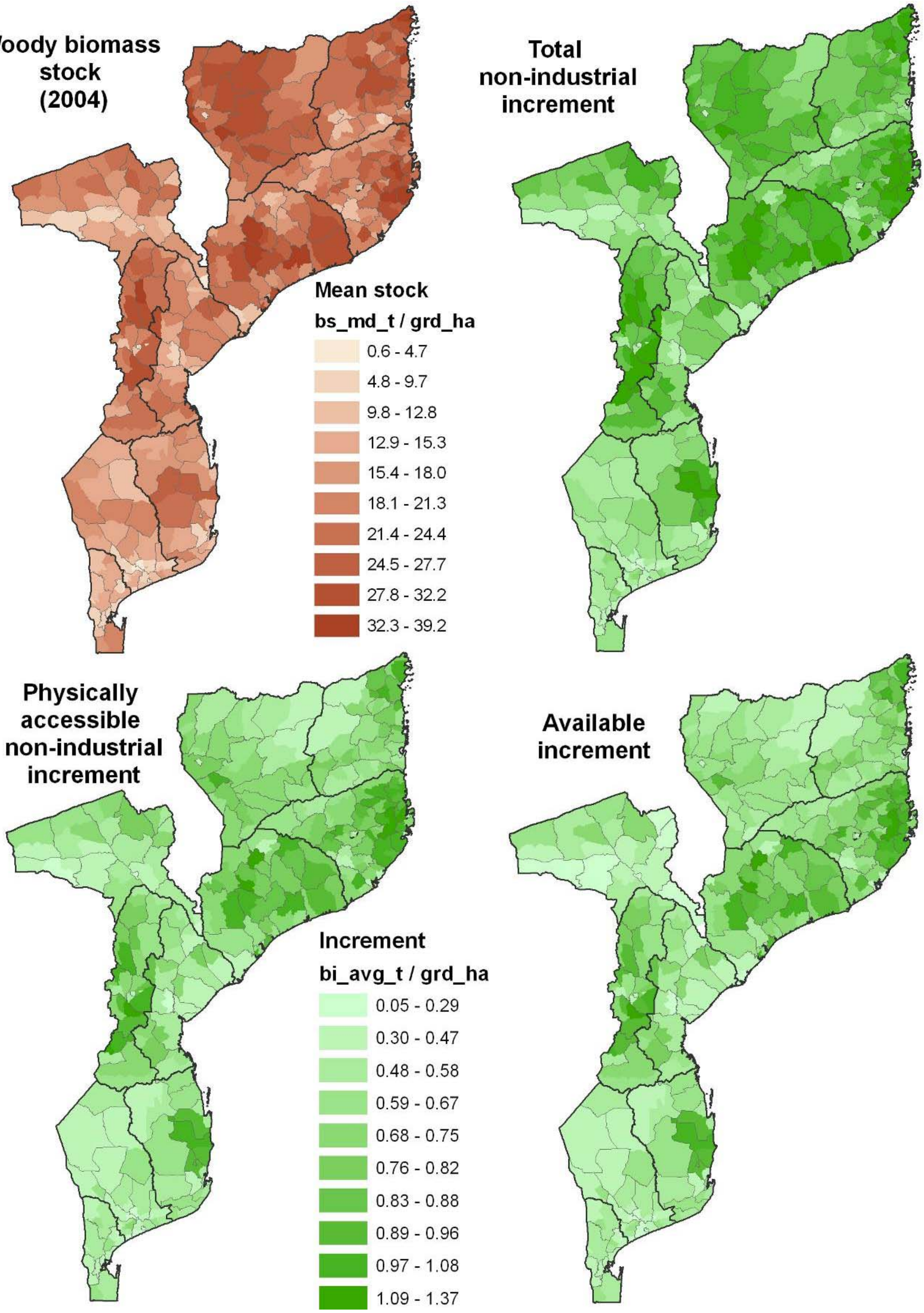


Figure 10 : Woody biomass stoch and increment categories by administrative unit (Posto Administrativo)



3.4 Integration module

The first and most important result of the integration module is the balance between supply potential and current consumption. This analysis was carried out at two subsequent levels: firstly at **local level**, to assess the supply/demand balance for each pixel or within a limited radius and secondly at **commercial level**, considering local surplus suitable for commercial woodfuel production and local deficit areas.

Integration of supply, demand and balance data with other thematic layers, i.e. socio-economic parameters, poverty indicators, infrastructures, services, etc.. is possible and highly recommended. The combination at geographic levels of wood energy and other aspects will produce new and additional insight on the multi-faceted wood energy issue that will certainly increase the understanding and the capacity to formulate sound policies and plans well adapted to true local conditions. Due to lack of time and ready-to-use data this additional level could not be carried out so far but it's strongly recommended to expand the range of integration analysis on priority themes as soon as clear interests are expressed.

3.4.1 Local balance

Pixel-level balance

The supply/demand balance at pixel level is calculated by deducting the pixel-level consumption from the pixe-level available productivity (see productivity categories in Section 3.3.3 “Overview of supply potential”).

The pixel-level local balance map is shown in Figure 11. Another higher resolution example of the pixel-level map is in Figure 12 (left side). Provincial summary of local balance statistics are given in Table 4 while District-level statistics are given in Annex 8.

Local neighborhood balance

The calculation of supply/demand balance by pixel has a useful accounting function but it represents a somewhat virtual balance since individual cells are usually either a production or a consumption site. More meaningful is to represent the relation between the consumption and the supply potential within a surface somewhat related to the real supply context. In case of local household consumption in rural areas such horizon is represented by the distance that household's members are prepared to go to fetch fuelwood, on foot or by local transport mean. In order to visualize this factor, through the FOCALMEAN function, the balance of each cell was calculated as the balance between the mean supply and consumption values within a 5 km circle around each cell.

An example of pixel and neighborhood balance covering the Beira-Chimoio area is shown in Figure 12.

Comparing the two maps it's evident how some deficit areas (at pixel-level) reach surplus conditions when analyzed in a 5 km radius (bottom-left ant top-right of the maps). At the same time, deficit areas of few pixels may remain negative even on the 5 km horizon, thus better revealing the consumption site (top-center of the maps).

3.4.2 Commercial balance

The commercial balance was analyzed with the purpose of determining the realistic sustainable supply zone of major woodfuel markets such as those of urban areas, bioenergy planning and future biomass power plants as well as for export purposes.

In the definition of the “commercial” balance the supply side considered only the fraction of the surplus that may be regarded as available and suitable for market-oriented production systems, while the demand side considered the deficit resulting from the local supply/demand balance. This implied the accounting of deficit conditions of the local balance as such and the estimation of the commercial share of local surpluses, excluding protected areas, unproductive areas as well as low-productivity areas.

Completely excluded are the sources that are under legal restrictions for commercial exploitation (while allowing access for local non-commercial needs). These areas include national parks, other protected areas, *fazendas do bravio*, reserved forests, hunting reserves, etc. (see Figure 8 and Figure 13).

Besides legal constraints, the areas considered accessible should not present the physical characteristics that were used in the Land Unit study to map protective (i.e. non-productive) forest areas (Wolf and Lorenzini 2007). Two levels of protective constraints were considered, one more "conservative" and one more "liberal" as defined in Table 4.

Table 4: Protective forest areas under physical constraints to be excluded from the commercial supply potential. "Conservative" and "liberal" scenarios.

	Steepness		Geomorphic hazard
"Conservative"	moderately steep steep very steep	(15÷30%) (30÷60%) (≥ 60%)	ponding (temporary water-covered)
"Liberal"	steep very steep	(30÷60%) (≥ 60%)	

In addition, where legally accessible, the commercial supply potential is limited to the formations that guarantee an adequate sustainable production of wood for energy that justify transport and management costs. To assess potentially commercial sources some basic quantitative thresholds related to charcoal making were defined:

- One threshold concerned the minimum stocking required for profitable charcoal production considering average kiln size and collection distance (Mancini et al, 2007). Such stock threshold was set at 15 t / ha considering that below such level the cost of kiln preparation would be unprofitable.
- The second threshold concerned the rotation period determined by the estimated annual surplus of the local supply/demand balance: only the areas with surplus levels that guarantee rotation periods lower than 40 years were considered eligible. To reach such condition the available surplus must be above 0.375 ad t/ha/year.

Consequently, only the areas with a stock above 15 adt/ha, a surplus above 0.375 adt/ha/year and "productive" vocation were considered as potential commercial sources.

The geographic coverage of the various constraints that limit the commercial exploitation of local surplus are shown in Figure 13.

The commercial balance maps relative to the "conservative" and "liberal" definition of physical constraints are shown in Figure 14.

Administrative-level summary results

Maps of consumption and local/commercial balances by Posto Administrativo are shown in Figure 15.

Provincial summary of commercial balance statistics for the conservative and liberal variants are given in Table 5 while District-level statistics are given in Annex 8.

Figure 11: Local supply/demand balance

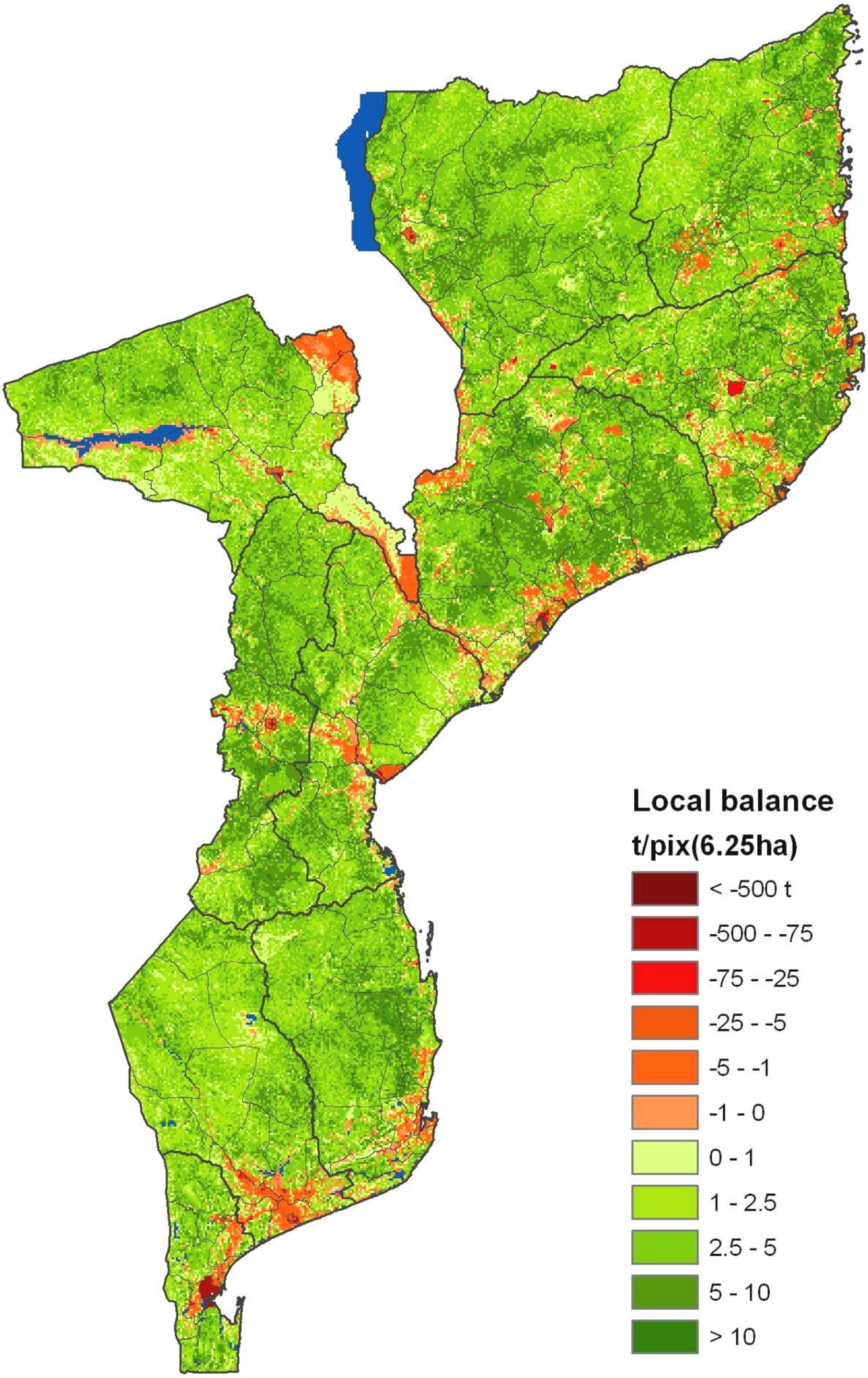


Figure 12: Local supply/demand balance assessed at pixel level and within a 5-km radious

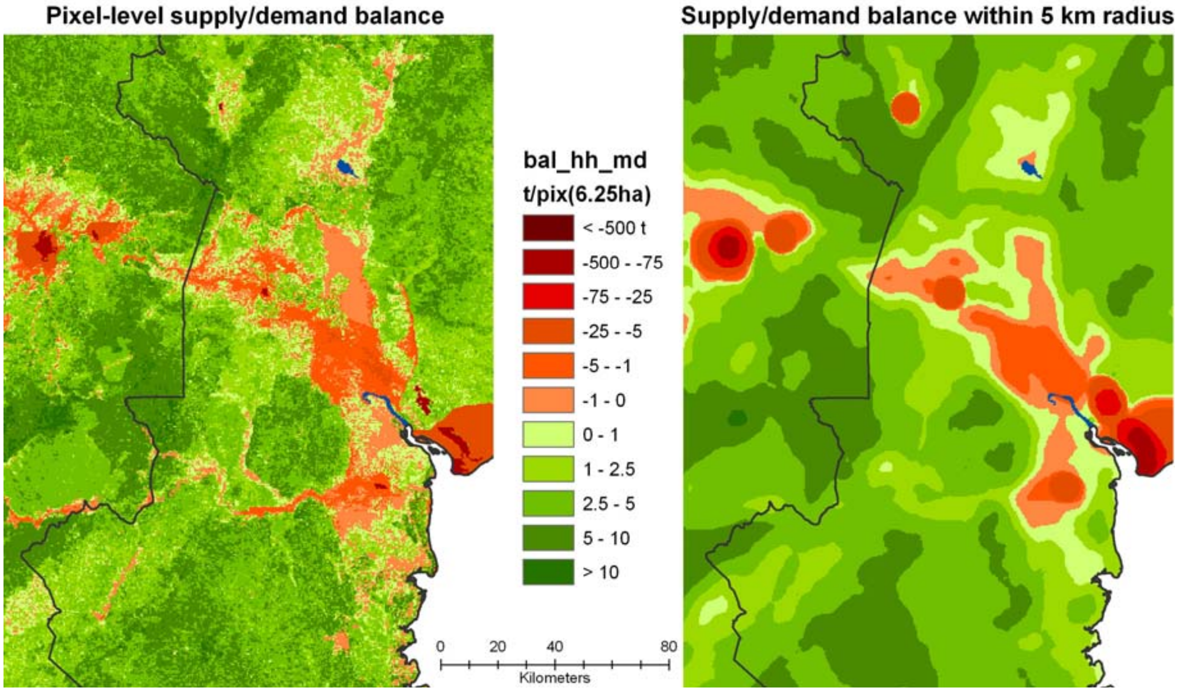


Figure 13: Main constraints to the utilization of local woody biomass surplus for commercial woodfuel markets

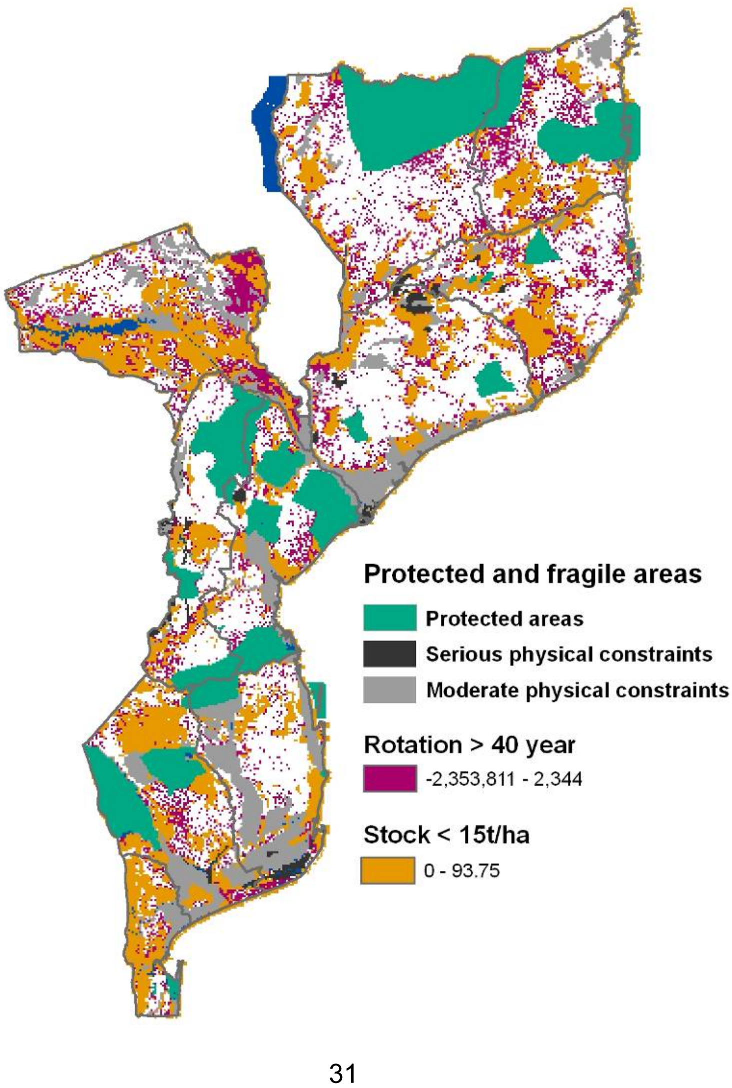


Figure 14: Commercial balance represented by local deficit areas and "commercial" surplus. Two situations are considered: a more conservative and a slightly more liberal definition of exploitation constraints.

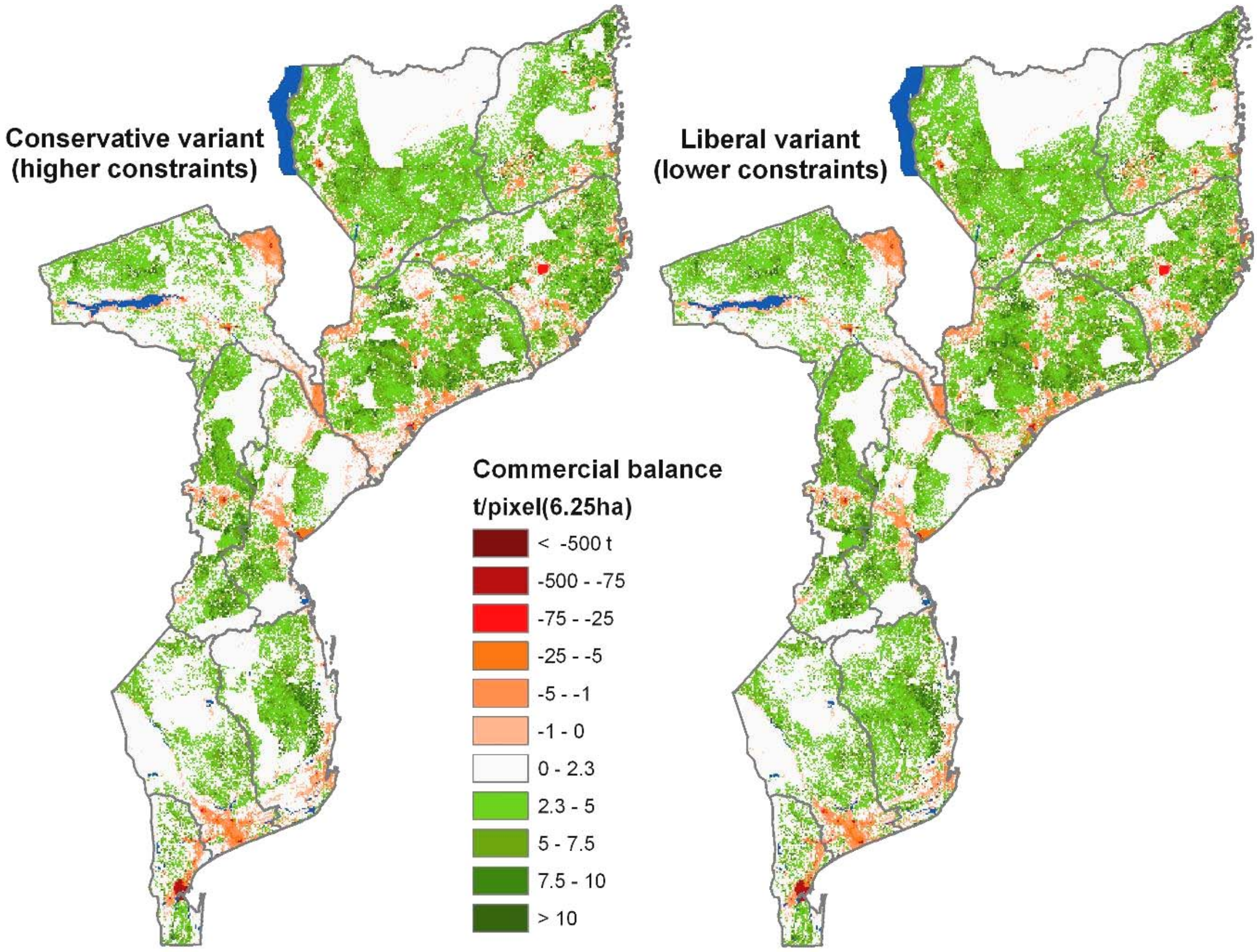
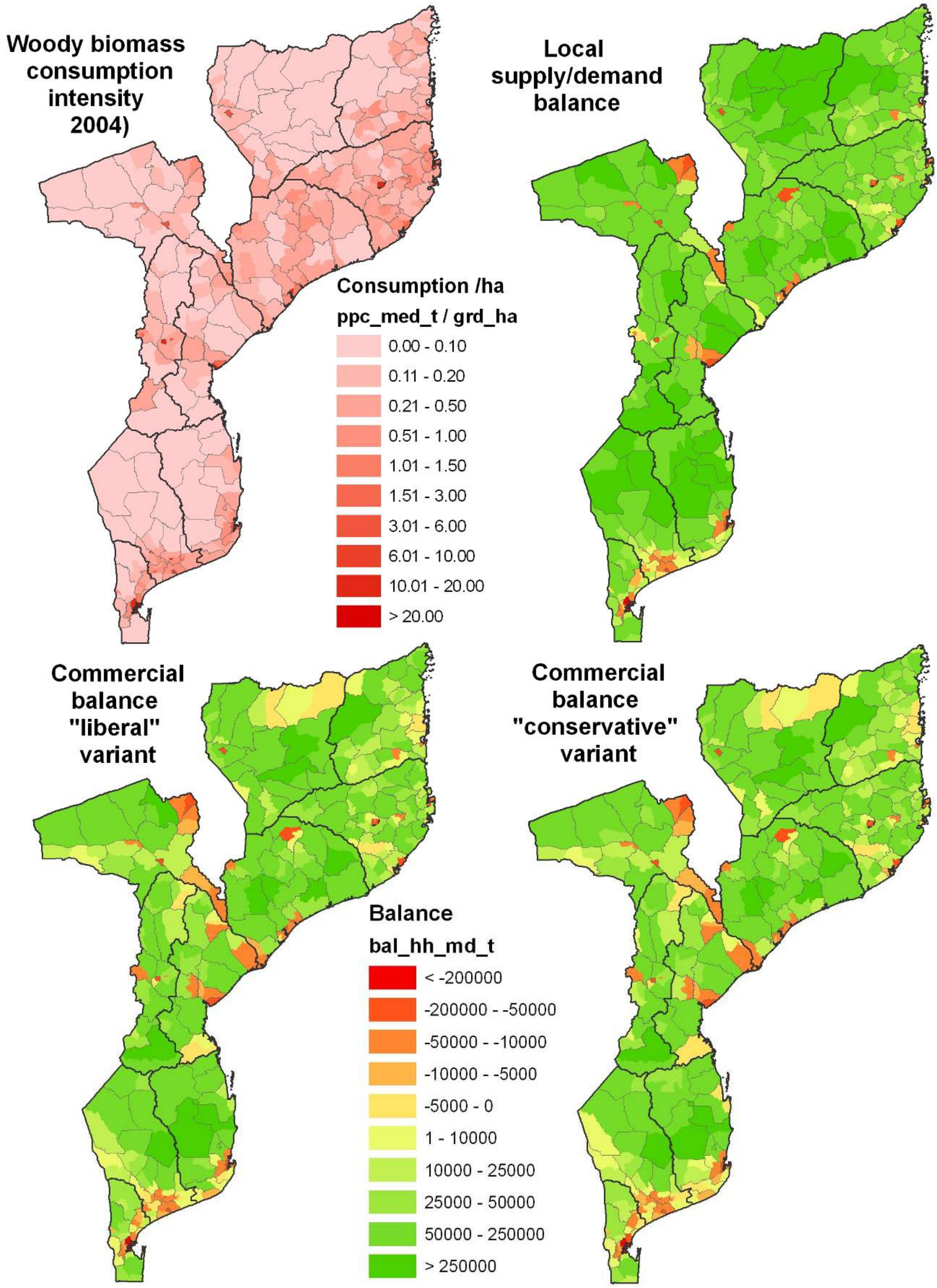


Table 5: Summary of WISDOM statistics by Province

Province	total Woody biomass stock	total non industrial increment	available increment physically accessible	residential and commercial consumption	local balance	commercial balance "liberal"	commercial balance "conservative"
	000 t	000 t	000 t	000 t	000 t	000 t	000 t
Niassa	308,447	10,607	6,977	749	6,228	3,757	3,600
Cabo Delgado	178,505	6,502	4,851	1,079	3,772	2,087	1,935
Nampula	169,033	6,868	5,885	2,755	3,131	2,226	2,095
Zambézia	248,529	9,745	7,862	2,526	5,336	3,988	3,635
Tete	169,455	6,876	4,188	1,114	3,074	1,921	1,425
Manica	144,755	5,843	4,594	937	3,657	1,997	1,885
Sofala	126,496	4,866	3,753	1,184	2,569	973	889
Inhambane	125,461	5,127	4,294	890	3,405	2,326	1,697
Gaza	112,708	4,345	3,382	863	2,519	977	821
Maputo	31,464	1,267	1,124	924	201	-204	-263
Maputo Capital	238	11	11	982	-971	-971	-971
Mozambique	**1,615,091**	**62,055**	**46,921**	**14,003**	**32,921**	**19,077**	**16,748**

Figure 15: Woodfuel consumption and local/commercial balance by administrative unit (Posto Administrativo)



3.5 Woodshed analysis

On the basis of commercial balance it is possible to outline the potential sustainable woodfuel supply zones of major cities and their area of influence, keeping into account the consumption of surrounding urban and rural areas as well as the resources realistically available. These zones are termed "woodsheds" (or "urban woodsheds", when specifically referring to urban consumption sites) in analogy with the familiar geographical concept of *water*sheds (FAO, in press).

The urban woodshed of a given city may be defined as the area around the city in which the balance between total woodfuel demand and the commercial surplus achieves stability (i.e., non-negative value).

Consumption outside the city is taken into account entirely as local deficit areas (local consumption higher than local productivity) but the surplus woody biomass (local productivity higher than local consumption) is limited to the "commercial" share, as discussed before while defining the commercial balance.

The estimation procedure for determining the woodshed of a selected city is to progressively expand the area around the city until the cumulative value of the commercial balance reaches positive value, which indicates that within such territory the supply potential matches the demand. This means that we assume that the entire surplus is managed to produce the requested amount of woodfuels. This is obviously a theoretical situation. It may be advisable, in fact, to assume different "management intensities" referring to the share of the resources that can be put under sustainable production regime within the area and a given time period. This means that actual supply will represent a fraction only of the entire potential supply. Accordingly, in order to achieve a balance condition the woodshed will increase its surface until a new balanced condition is reached.

An example of woodshed analysis for Maputo and for Beira-Chimoio is given in Figure 16. In this analysis, both "conservative" and "liberal" commercial balances were considered, which produced a significant impact on the size of the supply zone for Maputo but not for Beira-Chimoio. In addition, two different management regimes were assumed: a 100% regime, in which the entire commercial surplus was considered, and a 50% regime in which only half was considered. The regime intensity obviously produced a dramatic impact on the supply zones' size. With the lower management regime and the more conservative commercial balance the necessary supply zones of Maputo and Beira-Chimoio come to overlap slightly.

The socio-economic woodshed

Beyond "simple" biomass accounting, the urban woodshed helps to visualize and understand the complex and far-reaching urban/rural interface in both geographic and socio-economic terms. In fact, a clear vision of the territory concerned allows to identify the communities involved, in good or in bad, at present or in the future, in producing the woodfuels that the cities demand. The identification of the rural communities, the administrative units and their political entities, both urban and rural, constitutes the first essential step towards the development of sustainable wood energy systems in which environmental and socio-economic sustainability can be integrated. In fact, urban demand, usually seen as a threat on the surrounding forest resources can convert into an important and lasting opportunity for decentralized rural and forest communities if the sustainability is respected and the urban/rural relationship is formally recognized and based on principles of equity.

Degradation/deforestation risk zoning

The cause-effect mechanisms that lead to the loss of forest area is complex and rarely induced by a single cause. It's rather easy to see a relation between unsustainable fuelwood and charcoal production and forest degradation but, in spite of a common perception, it's not easy to prove a direct relation between woodfuel production and deforestation. On one hand it's indubitable that intense and unsustainable charcoal making can lead to heavy degradation or even complete loss of forest cover but, on the other hand, it's also true that fuelwood and charcoal production are very often simple byproducts of the expansion of cropland and shifting cultivation into previous forested lands. In the second case, for instance, a reduction of fuelwood and charcoal demand would do little to reduce the deforestation rate.

The WISDOM analysis doesn't assess loss or degradation of forest resources, for which a proper monitoring programme is required, nor can tell where and to which extent fuelwood and charcoal production may be directly responsible of the ongoing processes of deforestation and degradation. It may, however, define varying intensities of risk of forest degradation and/or deforestation by segmenting the nominal sustainable supply zone of a city (urban woodshed) into risk zones along a gradient of accessibility.

Figure 17 shows an example of risk zoning within the Maputo woodshed in which the risk level is set to be inversely proportional to the distance from the city and within the estimated sustainable supply zone.

Figure 16: Woodshed analysis for Maputo and Beira-Chimoio. Sustainable supply zones based on conservative/liberal constraints assumptions (producing no significant difference for Beira-Chimoio zones) and on 100%-50% management regimes.

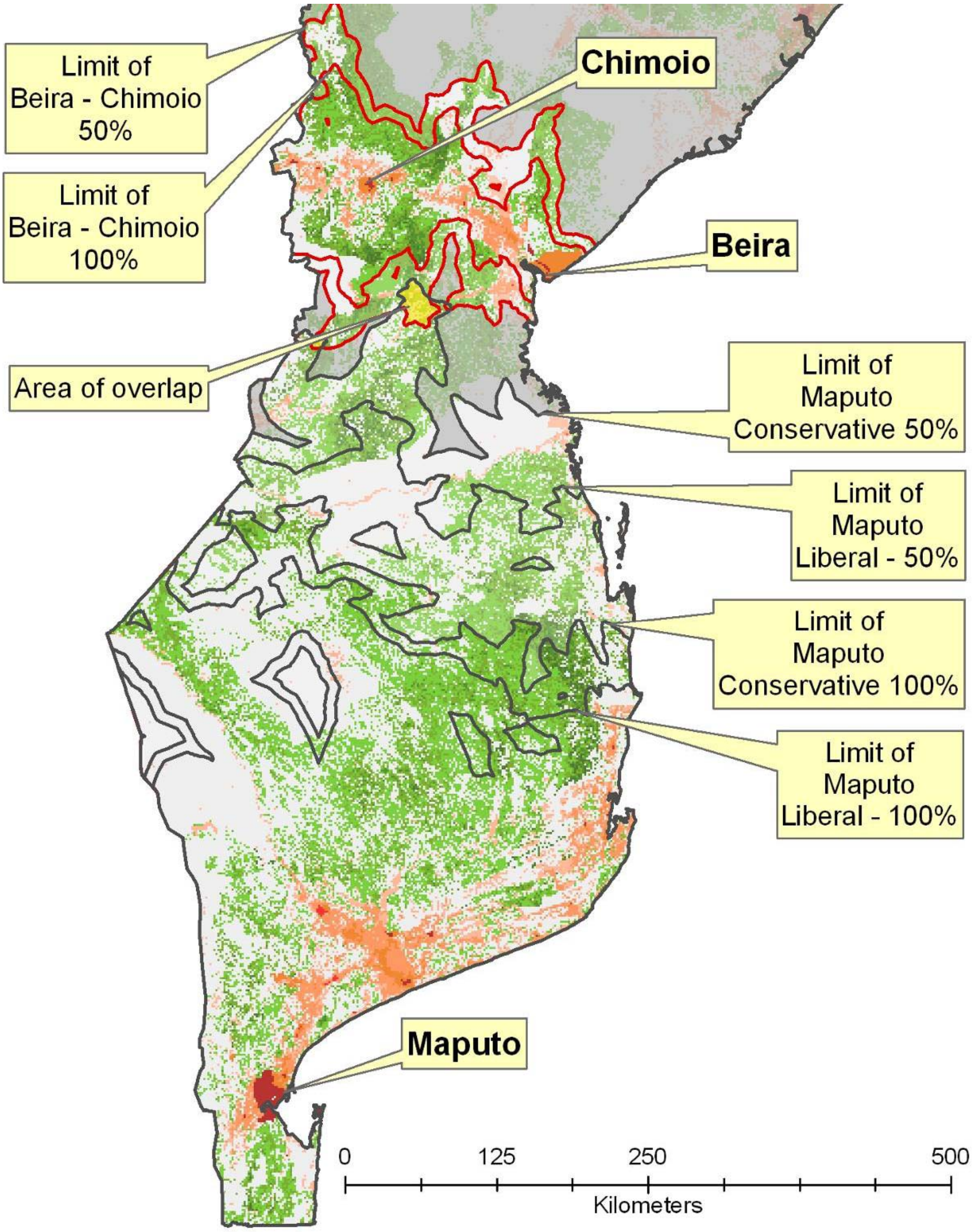
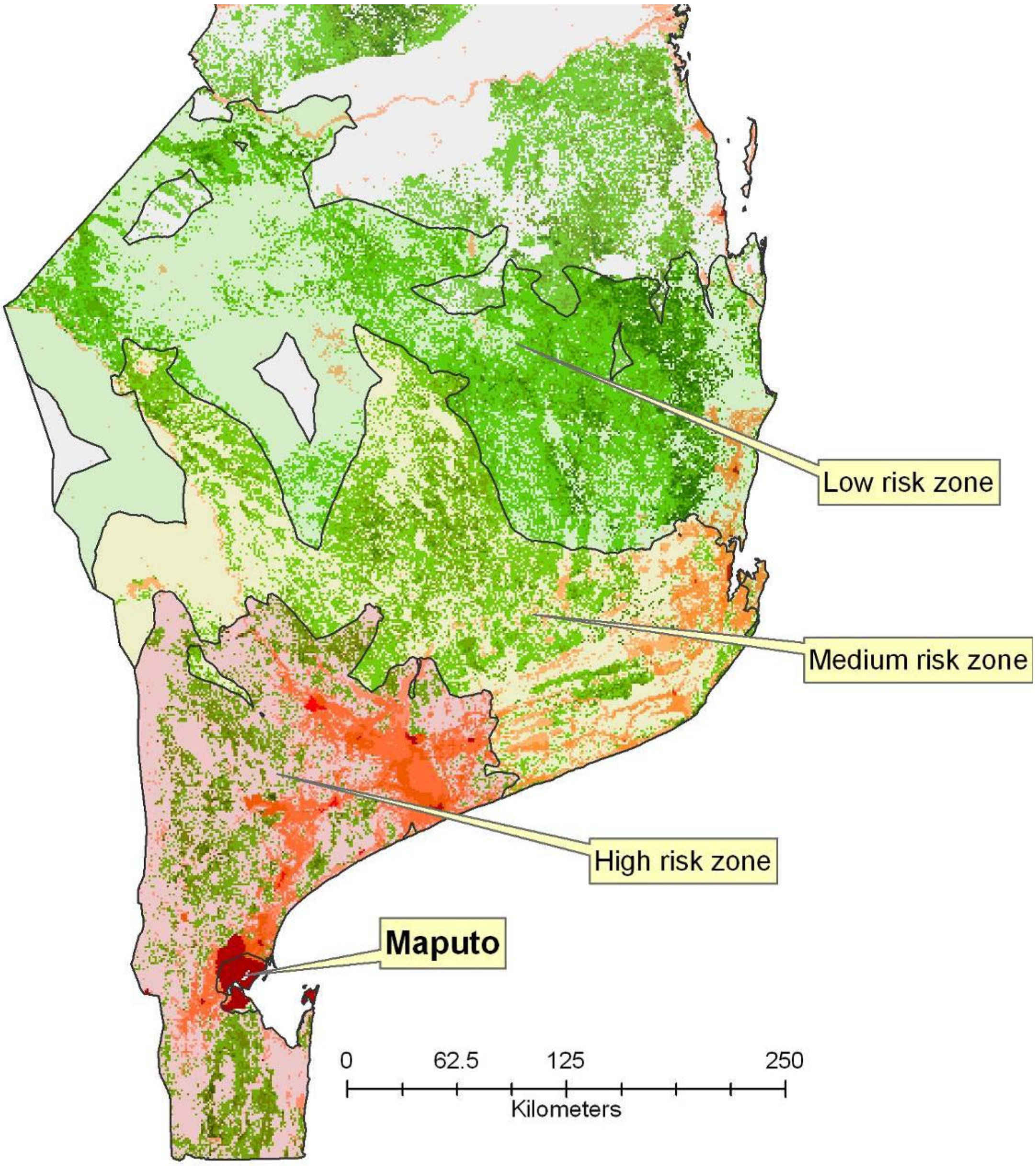


Figure 17: Degradation risk zoning within the Maputo's sustainable supply zone.



4. Conclusions and recommendations

4.1 Conclusions

Results :

WISDOM Mozambique is conceived as a strategic planning tool to be maintained, deepened and, most important, used by forestry and energy and rural development planners concerned with wood energy. In this respect, the analytical conclusions, thematic maps and tables here presented should be considered as the first step in the analysis of this sector and not the conclusion of a process.

In fact, the main result of the activity is the WISDOM geodatabase, more than the single table and map that have been produced in the process, and the possibility of to "refresh" the system with new reliable parameters as they become available.

From the analysis carried out so far, for the time being limited to medium productivity and consumption levels, a wide variety of results were produced, ranging from stock and productivity estimates, consumption estimates and several local and commercial supply/demand balances, spatially (at 250m pixel level) as well as by administrative units of all levels. Amongst this wealth of data and findings, the following aspects may be highlighted:

- The total non-industrial productivity of woody biomass annually available for the entire country is estimated at 62 Mt ($t*10^6$, air dry) from which some 46.9 Mt are physically accessible and potentially available for energy use.
- The total consumption in the residential and commercial sector is estimated at 14 million t.
- At national level, there is a consistent surplus potential of woody biomass for both local and commercial exploitations. At sub-national and local levels, however, there is a marked variability and there are many areas of deficit:
  - At provincial level only the Province of Maputo and Maputo Capital show deficit conditions, with a cumulative "debit" of some 1.2 million t.
  - Niassa and Zambézia are the provinces with higher surplus, which is estimated at approximately half of the entire available potential.
  - At District level, 31 out of 148 Districts (21%) present a deficit condition at local balance level, fraction that rises to 41 (28%) for the "liberal" variant of the commercial balance, and to 46 (31%) for the "conservative" variant.
- Maputo's woodshed, which represents the territory necessary to provide a sustainable supply of woody biomass (as charcoal, mainly) to satisfy the consumers of Maputo and of all other enclosed cities and rural communities, is very big indeed, reaching as far as 450 km from the Capital and covering the entire Provinces of Maputo, Gaza and more than half of Inhambane (assuming that the whole available resource is managed).
- Still concerning Maputo woodshed, if we assume to put under sustainable production regime only half of the potential productivity, the distance from Maputo would reach over 600 km including, beyond Inhambane, the southern parts of Manica and Sofala.
- Within Maputo's woodshed we can define areas and resources under various levels of pressure and consequently under different levels of risk of degradation and of triggering processes of permanent deforestation. Considering the level of demand and the distribution of resources, it is estimated that the high risk zone reaches approximately 200 km from Maputo, while the medium risk zone covers a buffer of some 150 km beyond, reaching a distance of some 350 km. …

On a more general perspective, the WISDOM analysis already produced, or is expected to produce in the near future, the following benefits :

- <u>Holistic vision</u>. For the first time the wood energy issue can be visualized and analyzed over the entire country maintaining at the same time a local perspective.

- Priority areas definition. The local perspective and national consistency of analysis and parameters permits the identification of priority areas of intervention and/or further analysis.
- Valorization of existing data/knowledge. The need to feed the WISDOM modules with the best available information on supply and consumption aspects implied the review and use of every piece of information, study, survey etc. ever done over these subjects in the country, thus attributing value and function to information otherwise fragmented.
- Critical data gaps definition. A thorough review of the information available allowed the identification of data gaps that are really critical for a good understanding and for the formulation of sound policies.
- Optimize available resources. The identification of priority areas of intervention, in geographic as well as thematic terms, allows circumscribing and focusing future actions (resource management, additional data collection, etc.) and thus enhancing the efficiency and reducing the costs of such actions.
- Promote cooperation and synergies. The inter-sectoral and interdisciplinary character of WISDOM implies the exchange of information among agencies and it favors the discussion about the multifaceted wood energy "sector" over a common shared ground built with the contribution of each party. It is hoped that the use and maintenance of the WISDOM geodatabase will further strengthen these liaisons and inter-agency collaboration in the future. The role that WISDOM will play in the inter-institutional Advisory Group that supports the formulation of the National Biomass Plan will certainly promote further synergies among the DNTF, the University, energy agencies and other parties of the advisory group.
- Enhance visibility and political recognition. The integration of various aspects and the cartographic representation of result makes WISDOM easy-to-visualize and to some extents it makes a complex issue simple and, to some extent, attractive. This makes it more accessible to non technical readers and simplify the task to policy makers, who will be less reluctant towards a subject often considered "intractable".

Data limitations :

Reference data, such as the total woodfuel consumption in Cidades, Vilas and rural areas, are estimates rather than objective measurements since systematic consumption data was never collected and the availability of survey data was strongly unbalanced between Maputo, the other major and minor cities, and rural areas.

The estimation of woody biomass stocking and productivity was based on AIFM's National Forest Inventory data and Land Cover maps that provided solid information on forest classes but only indicative values for most non-forest classes. This means that for these classes the estimates cannot be more than "best approximations" based largely on poor references and inference.

In general, however, as may be explained by fuzzy logic, the maps integrating many parameters acquire a reliability of their own thanks to the concurrence of so many factors and in spite of the weakness of individual quantitative parameters. Field action may therefore be implemented with good confidence within the core priority areas, while additional data may be collected in order to build up more reliable quantitative estimates where the situation is less clear and investment appears justified.

It is not possible to estimate with precision the error associated with the results of the study, since the quantitative results were not based on a uniform statistical approach but rather on a mosaic of extremely heterogeneous statistical and cartographic data sources. An idea of the possible margin of error associated with biomass stocking and productivity may might be derived from the statistical confidence interval of inventory data for the forest strata used in the analysis. The values for stocking ranged around the mean, with a factor of between 0.76 and 1.24, and a similar factor range was assumed for the mean annual increment.

The results presented in this document refer exclusively to average productivity and consumption values, which produced average balance values. The forthcoming analysis based on minimum and maximum productivity and consumption values will allow to visualize the range of incertitude associate to current reference data and to determine and differentiate the "core" priority areas that are confirmed in all variants from the situations that are less certain.

Data layers needed:

In order to provide a reliable analysis of woodfuel supply and demand it's important to refresh regularly the reference data with accurate and up-to-date parameters as they become available.

One important updating that will soon be available concerns demographic data from the census of 2007, which will hopefully provide a new map of *localidades* and *aldeias* that will enhance rural population mapping. According to INE, the final results of the *3rd Censo Geral de População e Habitação 2007* will be released within June 2009 at province level and by November 2009 at national level.

In addition to the regular system maintenance it's recommended to upgrade the information concerning the following:

- Secondary road network. The available road map reports primary roads only and excludes the system of secondary roads and *pistas* that play an important role on the accessibility of forest resources.
- Woodfuel consumption in sectors other than residential and their distribution within the country (tobacco drying, fish smoking, brick making, etc..).
- Consumption and distribution of electricity and other energy carriers (gas, kerosene). Spatially discrete information on the penetration of alternative fuels for residential and industrial use will allow a better understanding of the substitution trends and potentials within the country.
- Profitable/non profitable wf sources. The distinction between the "commercial / non-commercial" sources of woody biomass was made on productive/protective aspects and not, so far, on economic aspects. It's therefore important to undertake investigations on this in order to develop a realistic assessment of the true commercial potential of woody biomass resources and their distribution.

4.2 Recommendations

- The importance of woodfuels as energy source for the majority of Mozambican people and its dominant role as forest product were well known even before the WISDOM analysis but now, thanks to the geostatistical information produced, it's possible to discriminate deficit and surplus areas with objectivity. It is therefore possible, and strongly recommended, to develop on such basis sustainable forest-energy strategies able to profit from the opportunities that the wood energy sector offers, where they exist, mitigating at the same time the negative impacts that unsustainable exploitation practices are producing in so many forest areas of the country. Among others, the following management options may be considered:
    - A system of forest concessions specifically oriented to fuelwood and charcoal production.
    - Definition of clear and formal urban-rural partnerships aiming at the satisfaction of urban needs respecting at the same time environmental sustainability and equity in the distribution of economic benefits.
    - Promote the creation of rural woodfuel markets and/or other forms of woodfuel producers associations and consortia oriented to secure a more sustainable use of the resources securing at the same time the perpetuity of the benefits.

- The WISDOM geodatabase integrates data derived from the National Forest Inventory carried out by AIFM with data coming from several institutions and research centers on a variety of topics dealing, mainly with woodfuel consumption aspects. The integration of cross-sectoral and interdisciplinary competences is essential for the efficiency of WISDOM and therefore it strongly recommended to maintain and further develop WISDOM Mozambique as a shared cross-sectoral and inter-disciplinary tool for bioenergy planning.

- In order to ensure the integration mentioned above it is recommended to strengthen the linkages with energy, agriculture and other planning agencies and to share the WISDOM geodatabase with the specific scope of verifying the underlying assumptions and sharing the responsibility of maintaining the reference information up-to-date.

- Complete the WISDOM analysis along the minimum and maximum productivity and consumption variants, in order to represent the variability induced by available data and to highlight the margin of confidence of the conclusions that the analysis suggests.

- Further integrate the analysis with socio-economic aspects that will help to understand the fuel substitution dynamics and develop realistic scenarios and forecasts. As a useful step in this direction it is recommended to use WISDOM data and the priority areas therein identified to conduct socio-economic analyses of sustainability, substitution trends.

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Annexes

Annex 1: Summary of main layers, variable and data sources of WISDOM modules

Module /phase	Layer/ parameter	Variable clave	Source de information	Comments
Spatial base	Map administrative (vector)	Provinces Districts	DINAGECA Available in AIFM	
		Postos Administrativos	INE Availible shapefile	Not perfectly matching district boundaries
		Populated places: 68vilas, 23 cidades; district capitals (points)	List of ciudades and vilas (urban entities) received from INE Aldeias point map (1997) already available in AIFM	Aldeias points are too inconsistent to be used. They are not actual settlements but rather pseudo centers of dispersed rural populations. In addition there are many obvious coordinate problems. Hopefully, the 2007 version will be better.
	Land cover	Mozambique 1:1,000,000 22 LCCS original classes; 9 Land regions (eco zones); 631 individual class combinations (map codes); 2277 “biounits”	AIFM	
		Maputo and Manica Provinces 1:250,000 38 LCCS classes	AIFM	
Spatial analysis (pix. 250m?)	DTM	DTM 90 m Slope map 90m	AIFM	
	Protected areas	3 categories of protected areas under the Min. of Tourism (Nat. Parks, ?; ?) .	AIFM; Min. Tourism. Maps available at AIFM to be checked by A. Fusari	In these areas the exploitation is allowed for subsistence needs of local communities, NOT for commercial purposes
		Reservas Florestais	AIFM	Probably only available for subsistence supplies and not for commercial purposes (like nat. parks, etc.)
		Fazendas de Breviu	Direccao Nacional de Terras e Florestas (DNTF)	Many Fazendas are digitized (Ref. Sr. Dique, DNTF) Original Info available with DNTF(Ref. ??) in form of paper maps
	Roads, railways	Permanent motorable roads	AIFM DINAGECA ; ANE Revised road database	The map of roads available in AIFM appears impreciseThe ANE map of communication infrastr. appears very limited
	Accessibi-lity	Cost-distance based on aldeias, cities, roads, railways, slope, lc (terrain) types and protected areas	AIFM	
Supply Module	Direct sources			
	Stock and productivity of Forest lands	Forest/land cover categories and main ecological zones. VOL>10 DBH (stem vol over bark)	Forest inventory - AIFM	

Module /phase	Layer/ parameter	Variable clave	Source de information	Comments
		Volume – biomass expansion factors and values allocation to forest classes	Forest inventory – AIFM; Almeida A. Sitoe e Flávia Tchaúque, AIFM 2007	Biomass by lc class will be based on DBH equations using sample plot data. As test/verification of BEF equations (Brown), make estimation also from VOB10
		Productivity	Mário Paulo Falcão, AIFM 2007	
	NON-energy use	Other NON-energy use of woody biomass (i.e. timber for industry & export; construction; etc.) to be deducted from the accessible productivity	Direccao Nacional de Terras e Florestas (DNTF) Provincial statistics	Two non-energy categories will be used: potential commercial productivity (from inventory data) and actual extraction values from DNTF statistics. These will be incremented by an “informal” fraction for small industries and for construction material
	Spatial proxy for values distribution within the classes	Tree cover percent	MODIS Vegetation Continuous Field Tree Cover Percent at year 2000	Reasonable match with land cover classes. The use as proxy of intra-class distribution appears justified.
		Land cover change rates	Manica Province only AIFM	The change rate will be used to project resource availability in (near) future. The changes will be analyzed also in relation to the detailed study on charcoal (and NWFP) in Muda (Manica Prov.)
Cont./ Supply Module	Stock and productivity of NON-Forest lands	Biomass stock and productivity allocation to non-forest classes: Short fallow shifting cultivation, Trees outside forest Orchards Croplands, Urban areas etc	??? (Inference, mainly) Check vegetation structure of non-forest classes through Google Earth “reconnaissance” Special studies for main agricultural tree and shrub crops.	
	Indirect sources			
	Residues from forest industries	Geographic distribution of the forest industries (sawmills, other wood processing; pulp and paper industries [chemical, semi-chemical])	DNTF; Inquerito a industria madereira (Eureka Lda 2001?) Rel. 2006 on Sofala, Zambézia and Cabo Delgado (Rural Consul SAVCOR-INDUFOR Rep 6253)	The 2001 national report has addresses of industries useful for geog. distribution but is rather old. The 2006 rep on 3 provinces is updated but has no addresses
		Processed material; products stats;	DNTF Yearbooks 2003-2006 SAVCOR-INDUFOR 2006 (3 prov.) Eureka 2001 for other prov.)	
		Estimation of residues generated (fraction of processed wood or final product)	Review special studies, thesis etc. produced by UEM. Ref. Dr. Egas, UEM ??	
		Production of black liquor by pulp and paper industry		There is no p&p industry as yet in Mozambique
	Recovered woody biomass	Pallets; Construction wood;		

Module /phase	Layer/ parameter	Variable clave	Source de information	Comments
Demand Module	Household consumption	Consumption of fuelwood and charcoal per capita (per household) in rural and urban areas;	CHAPOSA study Duarte & Nakala (FAO, 2000) Brower & Falcão, 2001 (CHAPOSA/FAEF/DEF) Dir. Nat. Energia - Novas e Renovaveis (Eng. Marcelina Mataveia: New consumption study (to be complete in Dec. 07) in rural/urban areas of various (6) provinces (supp. by DANIDA); Ref. person Almeida A. Sitoe. PIED, 1997.	Falcao provided the relevant reports on Friday 14 with consumption estimates in comm. sector of Maputo. Sitoe provided relevant documents and prelim. results of consumption survey. In any case a formal request of this data must be sent from DNTF to Min. Energia.
		As complementary variables: consumption (and penetration) of other fuels (gas, kerosene, electricity)	Dir. Nat. Energia - Combustiveis (Eng. ??)	
		Electricity distribution map	Dir. Nat. Energia - Electicidad does not have a GIS unit	The electrical network will allow to separate the communities that may have / not have access to it.
		Demographic data 1997 (households, percapita) by: Rural; Vilas; Cidades	INE CENSO 1997 list of cidades and vilas Censo 2007 by District only.	In order to obtain more updated population figures the 1997 values within each district (P.A., Localidades, Aldeuias) will be adjusted according to 2007 population results.
		Digitized urban areas (68 vilasand 23 cidades) in two categories: City centers: built up, industrial, infrastructure, farming<10%; Urbanized periphery: residential and farming (with farming 10-70%); (Farming > 70% = rural)	To be completed using Landsat/GoogleEarth	The two urban classes (centers and peripheries) will allow a more discrete differentiation of consumption patterns
Cont./ Demand Module	Consumed by industrial processes	Consumption of woody biomass (residues) by the forest industries	Special studies? INE (?) Min. Energia (?)	
		Consumption of woody biomass (residues) by agro-food industry and other industries: The (chá) drying; tobacco drying; fish smoking; ceramics; brick making; blacksmith; etc.)	NO structured data available! Possible sources: UEM, INE (?) Min. Energia (?) Census agropequario Special studies? Interview major operators.	
		Industry of pulp and paper		There is no p&p industry as yet in Mozambique
	Consumption in the Commercial sector	Commercial services; Restaurants (Grills) Bread making	Special studies: Brower & Falcao 2001 Min. Energia (?) INE (?)	

Annex 2: Stock and increment by land cover/land region classes

Table A2.a : Description of Land Cover Classes and Land Regions

#	LC_CODE	Land Cover description
1	2FE	(Semi-) Evergreen forests
2	2FD	(Semi-) Deciduos forests
3	2WE	(Semi-) Evergreen woodlands
4	2WD	(Semi-) Deciduous woodlands
5	4FF	Mangrove dense
6	4WF	Aquatic / Regularly Flooded Woodlands
7	2TK	Thickets
8	2SL	Shrublands
9	4SF	Aquatic / Regularly Flooded Shrublands
10	2FXC	Forest with shifting cultivation
11	2GL	Grasslands
12	4HF	Aquatic / Regularly Flooded herbaceous veg.
13	1CXF	Shifting cultivation with forest
14	1TC	Tree crops
15	1SC	Shrub Crops
16	1FC	Field crops
17	1HC	Herbaceous Crops
18	3AC	Cultivated Aquatic or Regularly Flooded Areas
19	5BU	Built Up Areas
20	6BA	Bare Areas
21	7WB	Artificial Waterbodies
22	8WB	Natural Waterbodies

LRE_CODE	Land Region description
1	Florestas (semi)-sempreverdes úmidas de montanha, pradarias de montanha e miombo úmido
2	Florestas úmidas sub-litoral
3	Miombo medio
4	Miombo seco
5	Florestas secas deciduas indiferenciadas
6	Florestas de mopane
7	Zonas sub-aridas e pradarias secas
8	Mosaicos de vegetação costiera e matagais e mangais
9	Areas inundadas

Table A2.b : Summary table of minimum, medium and maximum stock and increment by land cover/land regions combinations

			Total woody biomass stock (ad t/ha)			**Mean incr. as % of stock**	**Total woody biomass increment** (ad t/ha)			**Non-industrial increment** (ad t/ha)		
BIO_NAME	LAND_ COVER	LRE_ CODE	Mean BIOSTOCK	Minimum BIOSTOCK	Maximum BIOSTOCK	PERC_ INCR	AVG_ INCR	LOW_ INCR	UP_ INCR	AVG_ INCR	LOW_ INCR	UP_ INCR
Closed moist	2FD	1	44.37	41.31	47.42	3.34	1.48	1.38	1.58	1.15	1.07	1.23
Closed moist	2FE	1	44.37	41.31	47.42	3.34	1.48	1.38	1.58	1.15	1.07	1.23
Closed moist	2FD	2	44.37	41.31	47.42	3.02	1.34	1.25	1.43	1.04	0.97	1.12
Closed moist	2FE	2	44.37	41.31	47.42	3.02	1.34	1.25	1.43	1.04	0.97	1.12
Closed moist	2FD	3	44.37	41.31	47.42	3.06	1.36	1.27	1.45	1.06	0.99	1.13
Closed moist	2FE	3	44.37	41.31	47.42	3.06	1.36	1.27	1.45	1.06	0.99	1.13
Closed moist	2FD	4	44.37	41.31	47.42	2.89	1.28	1.19	1.37	1.00	0.93	1.07
Closed moist	2FE	4	44.37	41.31	47.42	2.89	1.28	1.19	1.37	1.00	0.93	1.07
Closed moist	2FD	5	44.37	41.31	47.42	2.45	1.09	1.01	1.16	0.85	0.79	0.91
Closed moist	2FE	5	44.37	41.31	47.42	2.45	1.09	1.01	1.16	0.85	0.79	0.91
Closed moist	2FD	8	44.37	41.31	47.42	2.78	1.23	1.15	1.32	0.96	0.90	1.03
Closed moist	2FE	8	44.37	41.31	47.42	2.78	1.23	1.15	1.32	0.96	0.90	1.03
Closed moist	2FD	9	44.37	41.31	47.42	2.61	1.16	1.08	1.24	0.90	0.84	0.96
Closed moist	2FE	9	44.37	41.31	47.42	2.61	1.16	1.08	1.24	0.90	0.84	0.96
Tree crops	1TC	1	40.00	31.20	48.80	4.00	1.60	1.25	1.95	1.60	1.25	1.95
Tree crops	1TC	2	40.00	31.20	48.80	4.00	1.60	1.25	1.95	1.60	1.25	1.95
Tree crops	1TC	3	40.00	31.20	48.80	4.00	1.60	1.25	1.95	1.60	1.25	1.95
Tree crops	1TC	4	40.00	31.20	48.80	4.00	1.60	1.25	1.95	1.60	1.25	1.95
Tree crops	1TC	5	40.00	31.20	48.80	4.00	1.60	1.25	1.95	1.60	1.25	1.95
Tree crops	1TC	6	40.00	31.20	48.80	4.00	1.60	1.25	1.95	1.60	1.25	1.95
Tree crops	1TC	7	40.00	31.20	48.80	4.00	1.60	1.25	1.95	1.60	1.25	1.95
Tree crops	1TC	8	40.00	31.20	48.80	4.00	1.60	1.25	1.95	1.60	1.25	1.95
Tree crops	1TC	9	40.00	31.20	48.80	4.00	1.60	1.25	1.95	1.60	1.25	1.95
Open moist	2WD	1	34.34	29.61	39.07	4.31	1.48	1.28	1.68	1.15	1.00	1.31
Open moist	2WE	1	34.34	29.61	39.07	4.31	1.48	1.28	1.68	1.15	1.00	1.31
Open moist	2WD	2	34.34	29.61	39.07	3.90	1.34	1.15	1.52	1.04	0.90	1.19
Open moist	2WE	2	34.34	29.61	39.07	3.90	1.34	1.15	1.52	1.04	0.90	1.19
Open moist	2WD	3	34.34	29.61	39.07	3.96	1.36	1.17	1.55	1.06	0.91	1.21
Open moist	2WE	3	34.34	29.61	39.07	3.96	1.36	1.17	1.55	1.06	0.91	1.21
Open moist	2WD	4	34.34	29.61	39.07	3.73	1.28	1.10	1.46	1.00	0.86	1.14
Open moist	2WE	4	34.34	29.61	39.07	3.73	1.28	1.10	1.46	1.00	0.86	1.14
Open moist	2WD	5	34.34	29.61	39.07	3.17	1.09	0.94	1.24	0.85	0.73	0.96
Open moist	2WE	5	34.34	29.61	39.07	3.17	1.09	0.94	1.24	0.85	0.73	0.96
Open moist	2WD	8	34.34	29.61	39.07	3.59	1.23	1.06	1.40	0.96	0.83	1.10
Open moist	2WE	8	34.34	29.61	39.07	3.59	1.23	1.06	1.40	0.96	0.83	1.10
Open moist	2WD	9	34.34	29.61	39.07	3.37	1.16	1.00	1.32	0.90	0.78	1.03
Open moist	2WE	9	34.34	29.61	39.07	3.37	1.16	1.00	1.32	0.90	0.78	1.03
Mangroves	4FF	1	30.00	23.40	36.60	3.00	0.90	0.70	1.10	0.90	0.70	1.10
Mangroves	4FF	2	30.00	23.40	36.60	3.00	0.90	0.70	1.10	0.90	0.70	1.10
Mangroves	4FF	3	30.00	23.40	36.60	3.00	0.90	0.70	1.10	0.90	0.70	1.10
Mangroves	4FF	4	30.00	23.40	36.60	3.00	0.90	0.70	1.10	0.90	0.70	1.10
Mangroves	4FF	5	30.00	23.40	36.60	3.00	0.90	0.70	1.10	0.90	0.70	1.10
Mangroves	4FF	6	30.00	23.40	36.60	3.00	0.90	0.70	1.10	0.90	0.70	1.10
Mangroves	4FF	7	30.00	23.40	36.60	3.00	0.90	0.70	1.10	0.90	0.70	1.10
Mangroves	4FF	8	30.00	23.40	36.60	3.00	0.90	0.70	1.10	0.90	0.70	1.10

			Total woody biomass stock (ad t/ha)			Mean incr. as % of stock	Total woody biomass increment (ad t/ha)			Non-industrial increment (ad t/ha)		
BIO_NAME	LAND_ COVER	LRE_ CODE	Mean BIOSTOCK	Minimum BIOSTOCK	Maximum BIOSTOCK	PERC_ INCR	AVG_ INCR	LOW_ INCR	UP_ INCR	AVG_ INCR	LOW_ INCR	UP_ INCR
Mangroves	4FF	9	30.00	23.40	36.60	3.00	0.90	0.70	1.10	0.90	0.70	1.10
Closed dry	2FD	6	29.36	20.03	38.68	3.14	0.92	0.63	1.21	0.72	0.49	0.95
Closed dry	2FE	6	29.36	20.03	38.68	3.14	0.92	0.63	1.21	0.72	0.49	0.95
Closed dry	2FD	7	29.36	20.03	38.68	3.33	0.98	0.67	1.29	0.76	0.52	1.00
Closed dry	2FE	7	29.36	20.03	38.68	3.33	0.98	0.67	1.29	0.76	0.52	1.00
Open dry	2WD	6	23.05	15.32	30.78	4.00	0.92	0.61	1.23	0.72	0.48	0.96
Open dry	2WE	6	23.05	15.32	30.78	4.00	0.92	0.61	1.23	0.72	0.48	0.96
Open dry	2WD	7	23.05	15.32	30.78	4.24	0.98	0.65	1.30	0.76	0.51	1.02
Open dry	2WE	7	23.05	15.32	30.78	4.24	0.98	0.65	1.30	0.76	0.51	1.02
Long fallow moist	2FXC	1	23.77	18.27	29.26	6.00	1.43	1.10	1.76	1.11	0.86	1.37
Long fallow moist	2FXC	2	23.77	18.27	29.26	6.00	1.43	1.10	1.76	1.11	0.86	1.37
Long fallow moist	2FXC	3	23.77	18.27	29.26	6.00	1.43	1.10	1.76	1.11	0.86	1.37
Long fallow moist	2FXC	4	23.77	18.27	29.26	6.00	1.43	1.10	1.76	1.11	0.86	1.37
Long fallow moist	2FXC	5	23.77	18.27	29.26	6.00	1.43	1.10	1.76	1.11	0.86	1.37
Long fallow moist	2FXC	8	23.77	18.27	29.26	6.00	1.43	1.10	1.76	1.11	0.86	1.37
Long fallow moist	2FXC	9	23.77	18.27	29.26	6.00	1.43	1.10	1.76	1.11	0.86	1.37
Open forest flooded	4WF	1	34.34	29.61	39.07	4.31	1.48	1.28	1.68	1.48	1.28	1.68
Open forest flooded	4WF	2	34.34	29.61	39.07	3.90	1.34	1.15	1.52	1.34	1.15	1.52
Open forest flooded	4WF	3	34.34	29.61	39.07	3.96	1.36	1.17	1.55	1.36	1.17	1.55
Open forest flooded	4WF	4	34.34	29.61	39.07	3.73	1.28	1.10	1.46	1.28	1.10	1.46
Open forest flooded	4WF	5	34.34	29.61	39.07	3.17	1.09	0.94	1.24	1.09	0.94	1.24
Open forest flooded	4WF	6	23.05	15.32	30.78	4.00	0.92	0.61	1.23	0.92	0.61	1.23
Open forest flooded	4WF	7	23.05	15.32	30.78	4.24	0.98	0.65	1.30	0.98	0.65	1.30
Open forest flooded	4WF	8	34.34	29.61	39.07	3.59	1.23	1.06	1.40	1.23	1.06	1.40
Open forest flooded	4WF	9	34.34	29.61	39.07	3.37	1.16	1.00	1.32	1.16	1.00	1.32
Shrub crops	1SC	1	20.00	15.60	24.40	4.00	0.80	0.62	0.98	0.80	0.62	0.98
Shrub crops	1SC	2	20.00	15.60	24.40	4.00	0.80	0.62	0.98	0.80	0.62	0.98
Shrub crops	1SC	3	20.00	15.60	24.40	4.00	0.80	0.62	0.98	0.80	0.62	0.98
Shrub crops	1SC	4	20.00	15.60	24.40	4.00	0.80	0.62	0.98	0.80	0.62	0.98
Shrub crops	1SC	5	20.00	15.60	24.40	4.00	0.80	0.62	0.98	0.80	0.62	0.98
Shrub crops	1SC	6	20.00	15.60	24.40	4.00	0.80	0.62	0.98	0.80	0.62	0.98
Shrub crops	1SC	7	20.00	15.60	24.40	4.00	0.80	0.62	0.98	0.80	0.62	0.98
Shrub crops	1SC	8	20.00	15.60	24.40	4.00	0.80	0.62	0.98	0.80	0.62	0.98
Shrub crops	1SC	9	20.00	15.60	24.40	4.00	0.80	0.62	0.98	0.80	0.62	0.98
Shrubs flooded	4SF	1	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.76	0.41	1.12
Shrubs flooded	4SF	2	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.76	0.41	1.12
Shrubs flooded	4SF	3	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.76	0.41	1.12
Shrubs flooded	4SF	4	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.76	0.41	1.12
Shrubs flooded	4SF	5	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.76	0.41	1.12
Shrubs flooded	4SF	6	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.76	0.41	1.12
Shrubs flooded	4SF	7	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.76	0.41	1.12
Shrubs flooded	4SF	8	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.76	0.41	1.12
Shrubs flooded	4SF	9	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.76	0.41	1.12
Shrubs/Thickets	2SL	1	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Shrubs/Thickets	2TK	1	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Shrubs/Thickets	2SL	2	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Shrubs/Thickets	2TK	2	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Shrubs/Thickets	2SL	3	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87

			Total woody biomass stock (ad t/ha)			Mean incr. as % of stock	Total woody biomass increment (ad t/ha)			Non-industrial increment (ad t/ha)		
BIO_NAME	LAND_ COVER	LRE_ CODE	Mean BIOSTOCK	Minimum BIOSTOCK	Maximum BIOSTOCK	PERC_ INCR	AVG_ INCR	LOW_ INCR	UP_ INCR	AVG_ INCR	LOW_ INCR	UP_ INCR
Shrubs/Thickets	2TK	3	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Shrubs/Thickets	2SL	4	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Shrubs/Thickets	2TK	4	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Shrubs/Thickets	2SL	5	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Shrubs/Thickets	2TK	5	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Shrubs/Thickets	2SL	6	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Shrubs/Thickets	2TK	6	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Shrubs/Thickets	2SL	7	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Shrubs/Thickets	2TK	7	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Shrubs/Thickets	2SL	8	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Shrubs/Thickets	2TK	8	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Shrubs/Thickets	2SL	9	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Shrubs/Thickets	2TK	9	19.09	10.16	28.02	4.00	0.76	0.41	1.12	0.60	0.32	0.87
Long fallow dry	2FXC	6	16.35	12.75	19.95	6.00	0.98	0.77	1.20	0.77	0.60	0.93
Long fallow dry	2FXC	7	16.35	12.75	19.95	6.00	0.98	0.77	1.20	0.77	0.60	0.93
Short fallow dry	1CXF	6	9.50	7.41	11.59	10.00	0.95	0.74	1.16	0.95	0.74	1.16
Short fallow dry	1CXF	7	9.50	7.41	11.59	10.00	0.95	0.74	1.16	0.95	0.74	1.16
Short fallow moist	1CXF	1	13.80	10.76	16.84	10.00	1.38	1.08	1.68	1.38	1.08	1.68
Short fallow moist	1CXF	2	13.80	10.76	16.84	10.00	1.38	1.08	1.68	1.38	1.08	1.68
Short fallow moist	1CXF	3	13.80	10.76	16.84	10.00	1.38	1.08	1.68	1.38	1.08	1.68
Short fallow moist	1CXF	4	13.80	10.76	16.84	10.00	1.38	1.08	1.68	1.38	1.08	1.68
Short fallow moist	1CXF	5	13.80	10.76	16.84	10.00	1.38	1.08	1.68	1.38	1.08	1.68
Short fallow moist	1CXF	8	13.80	10.76	16.84	10.00	1.38	1.08	1.68	1.38	1.08	1.68
Short fallow moist	1CXF	9	13.80	10.76	16.84	10.00	1.38	1.08	1.68	1.38	1.08	1.68
Grass savanna	2GL	1	6.00	4.68	7.32	6.00	0.36	0.28	0.44	0.36	0.28	0.44
Grass savanna	2GL	2	6.00	4.68	7.32	6.00	0.36	0.28	0.44	0.36	0.28	0.44
Grass savanna	2GL	3	6.00	4.68	7.32	6.00	0.36	0.28	0.44	0.36	0.28	0.44
Grass savanna	2GL	4	6.00	4.68	7.32	6.00	0.36	0.28	0.44	0.36	0.28	0.44
Grass savanna	2GL	5	6.00	4.68	7.32	6.00	0.36	0.28	0.44	0.36	0.28	0.44
Grass savanna	2GL	6	6.00	4.68	7.32	6.00	0.36	0.28	0.44	0.36	0.28	0.44
Grass savanna	2GL	7	6.00	4.68	7.32	6.00	0.36	0.28	0.44	0.36	0.28	0.44
Grass savanna	2GL	8	6.00	4.68	7.32	6.00	0.36	0.28	0.44	0.36	0.28	0.44
Grass savanna	2GL	9	6.00	4.68	7.32	6.00	0.36	0.28	0.44	0.36	0.28	0.44
Field crops	1FC	1	5.00	3.90	6.10	6.00	0.30	0.23	0.37	0.30	0.23	0.37
Field crops	1FC	2	5.00	3.90	6.10	6.00	0.30	0.23	0.37	0.30	0.23	0.37
Field crops	1FC	3	5.00	3.90	6.10	6.00	0.30	0.23	0.37	0.30	0.23	0.37
Field crops	1FC	4	5.00	3.90	6.10	6.00	0.30	0.23	0.37	0.30	0.23	0.37
Field crops	1FC	5	5.00	3.90	6.10	6.00	0.30	0.23	0.37	0.30	0.23	0.37
Field crops	1FC	6	5.00	3.90	6.10	6.00	0.30	0.23	0.37	0.30	0.23	0.37
Field crops	1FC	7	5.00	3.90	6.10	6.00	0.30	0.23	0.37	0.30	0.23	0.37
Field crops	1FC	8	5.00	3.90	6.10	6.00	0.30	0.23	0.37	0.30	0.23	0.37
Field crops	1FC	9	5.00	3.90	6.10	6.00	0.30	0.23	0.37	0.30	0.23	0.37
Built-up areas	5BU	8	2.00	1.56	2.44	10.00	0.20	0.16	0.24	0.20	0.16	0.24
Built-up areas	5BU	1	2.00	1.56	2.44	10.00	0.20	0.16	0.24	0.20	0.16	0.24
Built-up areas	5BU	2	2.00	1.56	2.44	10.00	0.20	0.16	0.24	0.20	0.16	0.24
Built-up areas	5BU	3	2.00	1.56	2.44	10.00	0.20	0.16	0.24	0.20	0.16	0.24
Built-up areas	5BU	4	2.00	1.56	2.44	10.00	0.20	0.16	0.24	0.20	0.16	0.24
Built-up areas	5BU	5	2.00	1.56	2.44	10.00	0.20	0.16	0.24	0.20	0.16	0.24

			Total woody biomass stock (ad t/ha)			Mean incr. as % of stock	Total woody biomass increment (ad t/ha)			Non-industrial increment (ad t/ha)		
BIO_NAME	LAND_ COVER	LRE_ CODE	Mean BIOSTOCK	Minimum BIOSTOCK	Maximum BIOSTOCK	PERC_ INCR	AVG_ INCR	LOW_ INCR	UP_ INCR	AVG_ INCR	LOW_ INCR	UP_ INCR
Built-up areas	5BU	6	2.00	1.56	2.44	10.00	0.20	0.16	0.24	0.20	0.16	0.24
Built-up areas	5BU	7	2.00	1.56	2.44	10.00	0.20	0.16	0.24	0.20	0.16	0.24
Built-up areas	5BU	9	2.00	1.56	2.44	10.00	0.20	0.16	0.24	0.20	0.16	0.24
Cultivated aquatic	3AC	1	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Cultivated aquatic	3AC	2	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Cultivated aquatic	3AC	3	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Cultivated aquatic	3AC	4	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Cultivated aquatic	3AC	5	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Cultivated aquatic	3AC	6	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Cultivated aquatic	3AC	7	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Cultivated aquatic	3AC	8	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Cultivated aquatic	3AC	9	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous crops	1HC	1	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous crops	1HC	2	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous crops	1HC	3	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous crops	1HC	4	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous crops	1HC	5	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous crops	1HC	6	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous crops	1HC	7	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous crops	1HC	8	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous crops	1HC	9	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous flooded	4HF	1	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous flooded	4HF	2	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous flooded	4HF	3	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous flooded	4HF	4	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous flooded	4HF	5	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous flooded	4HF	6	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous flooded	4HF	7	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous flooded	4HF	8	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Herbaceous flooded	4HF	9	1.00	0.78	1.22	7.00	0.07	0.05	0.09	0.07	0.05	0.09
Bare areas	6BA	All classes										
Water bodies	7WB	All classes										

Annex 3: Sectors, subsectors, branches and sub-branches of woodfuel end uses

PRODUCTIVE SECTOR	SUBSECTOR	BRANCH	SUB-BRANCH	WOODFUEL END USE
Primary	Agriculture	Crop production	- Grains and oilseeds - Tobacco	- Grain and oilseed drying - Tobacco curing
		Animal production	- Pigs - Poultry - Other	- Cooking feed - Poultry houses - Heating - Other
Secondary	Manufacturing industry	Food and beverages	- Sugar, granulated - Sugar, brown - Coffee - Tea - Tobacco - Herbs - Oils - Milk products - Bread - Confectionery - Maize tortillas - Tapioca meal	- Producing steam - Evaporating cane juice - Drying, roasting - Withering, drying - Curing - Drying - Producing steam - Steam - Baking - Cooking, sterilizing - Nixtamalization - Drying
		Metal minerals	- Iron - Steel	- Reduction, Smelting - Carbon restoration, blacksmithing
		Non-metal minerals	- Lime - Chalk - Cement - Tiles and brick - Pottery - Salt - Kaolin	- Calcination - Dehydration - Clinkering - Firing, ceramization, glazing - Firing, glazing - Evaporation-crystallization - Drying
		Pulp and paper	- Pulp and paper	- Steam and power for processing
		Wood-based products	- Wood	- Wood drying
Tertiary	Commerce and services	Food and beverages	Restaurants	- Food preparation
	Tourism and leisure		Hotels Camping sites	- Heating, hot water, food preparation, laundering
	Public	Health	Hospitals Schools	- Laundering - Food preparation

Source: FAO. 2002. A guide for woodfuel surveys. Prepared by T. A. Chalico and E. M. Riegelhaupt. EC-FAO Partnership Programme (2000-2002) Sustainable Forest Management Programme. See: http://www.fao.org/docrep/005/Y3779E/Y3779E00.HTM

Annex 4: List of “Fazendas do Bravio”

FAZENDAS DO BRAVIO EM FUNCIONAMENTO

FAZENDA DO BRAVIO	PROV.	DISTRITO	AREA (Há)	ACTIVIDADE	ANO ESTABEL. /PEDIDO
Cabo Delgado Biodiversity	C.Delgado	Macomia	32931.26	Turismo cinegetico	CM 2000
Sapap	Maputo	Moamba	10000	Turismo cinegetico	MINAG 2002
Sabie Game Park	Maputo	Moamba	40000	Turismo cinegetico	CM* 2000
Africaca	Gaza	Mabalane	5000	Criacao e exploracao de aves	MINAG 2003
Mbabala safaris	Gaza	Chicualacuala	20000	Turismo cinegetico	GP 2004
Imofauna	Gaza	Massangena	40000	Turismo cinegetico	GP 2005
Negomano Safaris	C.Delgado	Nairoto	10000	Turismo cinegetico	MINAG 2001
Mahimba Game Farm	Zambezia	Chinde	17600	Turismo cinegetico	CM 2000
Paul & Ubisse	Gaza	Massingir	30000	Turismo cinegetico	GP Parcelas 2002
Chikwirimiti	Gaza	Xai-Xai	40000	Criacao e exploracao de aves e repteis	MINAG 2002
Mozunaf Safaris	Sofala	Cheringoma	10000	Turismo cinegetico	MINAG 2002
Mafuia safaris	Manica	Macossa	45000	Turismo cinegetico	GP 2003
Cahora Bassa Safaris	Tete	Cahora Bassa		Criacao e exploracao de crocodilos	MINAG 2004
Schoeman	Tete	Mutarara		Criacao e exploracao de crocodilos	MINAG 2005
Mazinguele	Maputo	Variavel		Abate controlado de crocodilos	MINAG 2005
Eco Safaris Mucapana	Maputo	Moamba	2400	Eco Turismo	CM, MINAG 2005
Adolgo Bila	Gaza	Massingir	10000	Turismo cinegetico	GP 2004
Nguenha Project	Gaza	Massingir	10000	Turismo cinegetico	GP 2005
Kapenta Moçambique	Tete	Cahora Bassa	10	Criacao e exploracao de crocodilos	MINAG 2006
TOTAL DA AREA			**322941.26**		

Fazendas do Bravio em Processo de tramitacao ou pendentes

FAZENDA DO BRAVIO	PROV.	DISTRITO	AREA (Há)	ACTIVIDADE	ANO ESTABEL. /PEDIDO
Ntsewa Safaris	Cabo Delgado	Meluco	50312.5	Turismo cinegetico	2006
Eden Ranch Limitada	Sofala	Muanza	122000	Eco Turismo	2006
Ngalamo Safaris	Sofala	Muanza	22000	Turismo cinegetico	2006
Nhalikanga RFB	Inhambane	Govuro	13000	Turismo cinegetico	2006
Caia Wild Animal B& RI	Sofala	Caia		Turismo cinegetico	2006
Majune Safaris	Niassa	Majune	364403.5	Turismo cinegetico	2005
Lacerdonia Wilderness	Sofala	Marromeu	10000	Turismo cinegetico	2005
Eco-Turismo Alianca Moç	Maputo	Moamba	15000	Turismo cinegetico	
AAA Interprise	Maputo	Namaacha	200	Criacao e exploracao	2004
Sabie Investiment Lda	Maputo	Moamba	1600	Turismo cinegetico	2006
El Roy Lda	Maputo			Criacao e exploracao	2006
Mozamb Wildlife Advent	Niassa	Reserva do Niassa	295386	Turismo cinegetico	2006
Namoto Safaris Tur Pr 8040/827	Cabo Delgado	Palma	9500	Turismo cinegetico	2007
Fundacao Malonda	Niassa	Majune	100000	Conservacao e	2007
Sensa Senga Investimentos, Lda	Manica	Barue	20000	Turismo cinegetico	2007
Safari Mondzo Lda	Maputo	Magude	8000	Conservacao e	2007
Wildlife Manag Safaris	Gaza	Massingir		Criacao e exploracao	2007
Nharre Safaris	Gaza	Chicualacuala	10000	Turismo cinegetico	2007
MWA Mozambique	Niassa		71400	Turismo cinegetico	2007
Chaba Ingwe	Manica	machaze	18700	Turismo cinegetico	2007
Artemis Lda	Zambezia	Chinde	30000	Turismo cinegetico	2007
Muangaza	Cabo Delgado	Mocimboa da Praia	15000	Turismo cinegetico	2007
Muambe	Tete	Tete			2007
Crocodilos de Manica	Manica			Criacao e exploracao	2007
Agripec	Sofala				2004
TOTAL DA AREA			**1176502**		

Annex 5: Ranking of settlement suitability by land cover and road proximity

LC_CODE	ORDER_	LCCSNAME_E	DESCRIPTION	**Rural pop distribution factor** 100 = most suited for settlement 0= least suited for settlement Road buffer 500m	
				Along roads	**Far from roads**
2FE	1	Broadleaved Evergreen Trees // Semi-Evergreen Trees	(Semi-) Evergreen forests	**30**	**10**
2FD	2	Broadleaved Deciduous Trees // Semi-Deciduous Trees	(Semi-) Deciduos forests	**30**	**10**
2WE	3	Broadleaved evergreen // semi-evergreen woodland	(Semi-) Evergreen woodlands	**30**	**10**
2WD	4	Broadleaved Deciduous Woodland // Semi-Deciduous Woodland	(Semi-) Deciduous woodlands	**30**	**10**
4FF	5	Broadleaved evergreen forest on permanently flooded land (with daily variations); Major land class: Level land, Slope class: Flat to almost flat; Floristic aspect: Avennia marina, Ceriops tagal, Rhyzophora mucronata	Mangrove dense	**20**	**0**
4WF	6	Woodland On Permanently Flooded Land // Woodland On Temporarily Flooded Land	Aquatic / Regularly Flooded Woodlands	**20**	**5**
2TK	7	Closed Shrubland (Thicket)	Thickets	**40**	**10**
2SL	8	Open Shrubs (Shrubland)	Shrublands	**50**	**15**
4SF	9	Closed to Open Shrubs On Permanently Flooded Land // Closed to Open Shrubs On Temporarily Flooded Land	Aquatic / Regularly Flooded Shrublands	**20**	**5**
2FXC	10	Closed to Open Trees / Scattered Clustered Small Sized Field(s) Of Rainfed Herbaceous Crop(s)	Forest with shifting cultivation	**60**	**30**
2GL	11	Herbaceous Closed to Open Vegetation	Grasslands	**50**	**15**
4HF	12	Closed to Open Herbaceous Vegetation On Permanently Flooded Land // Closed to Open Herbaceous Vegetation On Temporarily Flooded Land	Aquatic / Regularly Flooded herbaceous vegetation	**20**	**5**
1CXF	13	Scattered Clustered Small Sized Field(s) Of Rainfed Herbaceous Crop(s) / Closed to Open Trees	Shifting cultivation with forest	**70**	**50**
1TC	14	Tree Crop(s)(fruits and timber)	Tree crops	**100**	**70**
1SC	15	Shrub Crop(s)	Shrub Crops	**100**	**70**
1FC	16	Herbaceous crop(s) // Shrub Crop(s)	Field crops	**100**	**70**
1HC	17	Herbaceous crop(s)	Herbaceous Crops	**100**	**70**
3AC	18	Cultivated Aquatic or Regularly Flooded Area(s)	Cultivated Aquatic or Regularly Flooded Areas	**70**	**50**
5BU	19	Built-up area(s)	Built Up Areas	**100**	**100**
6BA	20	Bare Area(s)	Bare Areas	**20**	**5**
7WB	21	Artificial perennial water bodies	Artificial Waterbodies	**0**	**0**
8WB	22	Perennial natural water bodies	Natural Waterbodies	**0**	**0**

Annex 6: Ranking of accessibility based on slope and terrain characteristics

Accessibility

10 = most accessible (minimum resistence)

270 = least accessible (maximum resistence)

Degrees slope

LC_CODE	ORDER_	DESCRIPTION	LC resisence factor	10	20	30	40	50	60	70	80	90
2FE	1	(Semi-) Evergreen forests	**2**	20	40	60	80	100	120	140	160	180
2FD	2	(Semi-) Deciduos forests	**2**	20	40	60	80	100	120	140	160	180
2WE	3	(Semi-) Evergreen woodlands	**1.5**	15	30	45	60	75	90	105	120	135
2WD	4	(Semi-) Deciduous woodlands	**1.5**	15	30	45	60	75	90	105	120	135
4FF	5	Mangrove dense	**5**	50	100	150	200	250	300	350	400	450
4WF	6	Aquatic / Regularly Flooded Woodlands	**5**	50	100	150	200	250	300	350	400	450
2TK	7	Thickets	**2**	20	40	60	80	100	120	140	160	180
2SL	8	Shrublands	**1.5**	15	30	45	60	75	90	105	120	135
4SF	9	Aquatic / Regularly Flooded Shrublands	**5**	50	100	150	200	250	300	350	400	450
2FXC	10	Forest with shifting cultivation	**1.25**	12.5	25	37.5	50	62.5	75	87.5	100	112.5
2GL	11	Grasslands	**1**	10	20	30	40	50	60	70	80	90
4HF	12	Aquatic / Regularly Flooded herbaceous vegetation	**5**	50	100	150	200	250	300	350	400	450
1CXF	13	Shifting cultivation with forest	**1.2**	12	24	36	48	60	72	84	96	108
1TC	14	Tree crops	**1**	10	20	30	40	50	60	70	80	90
1SC	15	Shrub Crops	**1**	10	20	30	40	50	60	70	80	90
1FC	16	Field crops	**1**	10	20	30	40	50	60	70	80	90
1HC	17	Herbaceous Crops	**1**	10	20	30	40	50	60	70	80	90
3AC	18	Cultivated Aquatic or Regularly Flooded Areas	**1**	10	20	30	40	50	60	70	80	90
5BU	19	Built Up Areas	**1**	10	20	30	40	50	60	70	80	90
6BA	20	Bare Areas	**1**	10	20	30	40	50	60	70	80	90
7WB	21	Artificial Waterbodies	**10**	100	200	300	400	500	600	700	800	900
8WB	22	Natural Waterbodies	**10**	100	200	300	400	500	600	700	800	900

Annex 7: Names and description of main maps[6]

Raster maps are at 250 m pixel size, unless otherwise specified.

Module/filename	Type	Description
Cartographic base		
PADM.SHP	Vec	Map of Postos Administrativos (PADM)
DISTRICT_PADMDIS	Vec	Map of Districts derived from PADM through dissolve
DISTRICT_PADM	rast	Raster map of Districts derived from PADM through dissolve
PROVINCE_PADMDIS	Vec	Map of Provinces derived from PADM through dissolve
PROVINCE_PADM	rast	Raster map of Provinces derived from PADM through dissolve
CIDADESVILAS_ALBERS	Vec	Vector map of INE's Cidades and Vilas based on GoogleEarth interpretation
POPPLACES_ORIGINAL	Point	Point map of populated places
POPPLACES_NOPOLY	Point	Point map of populated places for which there are no polygon maps
VDC.SHP	Vec	Communication network (primary roads, mainly)
PADM_01.mdb	.mdb	Geodatabase reporting supply, demand and balance results aggregated at level of Posto Administrativo (PA)
Accessibility maps		
SUPPLY_GRAV	rast	Raster of roads and populated places used as starting poi-distance analysis
LC_RESISTANCE	rast	Coefficient of crossing resistance of land cover classes
SLP250P_I	rast	Slope percent (integer values)
COST_LC_SLP3A	rast	Map combining slope and crossing resistence
SUPPLY_CD3A	rast	Cost distance map
AC3_40_100	rast	Accessibility map (between 40 and 100%) based on quantile segmentation of cost-distance map above
ADC_RAST0	rast	Raster version of protected areas (used as protected areas constraint)
LU_FC_RAST0	rast	Raster version of forest areas under physical constraint according to Land Unit study
FDB_RAST0	rast	Raster version of the the *fazendas de bravio* (used as legal constraint)
Supply Module		
TREECOVER	rast	Resampled MODIS Tree Cover Percent data (2000) (Hansen et al. 2003)
BIOUNITS	rast	Unique combinations of Land Cover combinations (map units) and Land Regions
AVG_TC_BIOU	rast	Average Tree Cover Percent value of Biounits
BS_MD_PP	rast	Woody biomass stock (ad t / pixel) – medium values
BS_MN_PP	rast	Woody biomass stock (ad t / pixel) – minimum values
BS_MX_PP	rast	Woody biomass stock (ad t / pixel) – maximum values
BI_AVG_PP	rast	Woody biomass increment (ad t / pixel) – medium values
BI_AVG_PP_TC	rast	Woody biomass increment (ad t / pixel) – medium values weighted on tree cover
BI_MD	rast	Accessible w. biom. increment (ad kg / pixel) – medium values
BI_MD_AV	rast	Available accessible w. biom. increment (ad kg / pixel) – medium values
BI_MN_AV	rast	Available accessible w. biom. increment (ad kg / pixel) – minimum values
BI_MX_AV	rast	Available accessible w. biom. increment (ad kg / pixel) – maximum values
W_IND_RES_KG	rast	Wood industries' residues associated to populated places

[6] For a complete description of the maps used and produced, the WISDOM Geodatabase and all other GIS-related aspects see the report of the Database/GIS Expert, Massimiliano Lorenzini.

Demand Module

POP2004	rast	Population per pixel estimated at year 2004
POP2004C	rast	Population per pixel of Cidades estimated at year 2004
PPC_MED_C	rast	Per pixel consumption in Cidades – medium values
POP2004V	rast	Population per pixel of Vilas estimated at year 2004
PPC_MED_V	rast	Per pixel consumption in Vilas – medium values
POP_PROB	rast	Rural population probability model (weighted overlay of urban proximity, road proximity and land cover types)
POP2004R	rast	Population per pixel of rural areas estimated at year 2004
PPC_MED_R	rast	Per pixel consumption in rural areas – medium values
PPC_MED	rast	Per pixel consumption in kg/pixel (whole country) – medium values
PPC_MIN	rast	Per pixel consumption in kg/pixel (whole country) – minimum values
PPC_MAX	rast	Per pixel consumption in kg/pixel (whole country) – maximum values
POLES_KG	rast	Consumption of w. biom. for construction material (poles, mainly), kg/pixel
DEDXTOB	rast	Deduction to be applied to productivity in each district for tobacco drying

Integration Module

BAL_HH_MD	rast	Local pixel-level balance btw available woody biom. increment and residential + commercial consumption – medium values
BAL_HH_MN	rast	Local pixel-level balance btw available woody biom. increment and residential + commercial consumption – minimum values
BAL_HH_MX	rast	Local pixel-level balance btw available woody biom. increment and residential + commercial consumption – maximum values
BALHHMD_F20	rast	5 km radius supply/demand balance – medium values
BALHHMN_F20	rast	5 km radius supply/demand balance – minimum values
BALHHMX_F20	rast	5 km radius supply/demand balance – maximum values
BAL_CO_MD_L	rast	commercial balance – medium supply and demand values, “liberal” variant
BAL_CO_MD_C	rast	commercial balance – medium supply and demand values, “conservative” variant

Woodshed analysis

CD3A_Z1_8	rast	Simplified cost map based on SUPPLY_CD3a to be used for woodshed delineation
MAPU137_5Z	rast	Supply zones of Maputo based on 137 cd buffers, liberal and conservative commercial balance variants and 100-50% management intensities
MAPUTO_5Z	vec	Vector version of above
BEI_CHI327_z3	rast	Supply zones of Beira and Chimoio based on 327 cd buffers, 100-50% management intensities (negligible liberal/conservative variations)
BEIRA_CHIMOIO_3z	vec	Vector version of above
MAPUTO_RISK_ZONES	vec	High, Medium and low forest degradation risk zones around Maputo

Annex 8: District-level summary of main WISDOM statistics

D_#	District	total Woody biomass stock	total non industrial increment	available increment physically accessible	residential and commercial consumption	local balance	commercial balance "liberal"	commercial balance "conservative"
		000 t	t	t	t	t	t	t
101	Cidade_de_Lichinga	248	11,668	11,364	116,012	-104,648	-104,648	-104,648
102	Cuamba	11,913	448,238	296,943	131,969	164,974	110,408	105,534
103	Lago	16,299	563,861	406,251	47,609	358,642	304,207	284,355
104	Lichinga	14,175	502,245	351,660	55,682	295,978	259,022	236,910
105	Majune	34,895	1,129,240	791,606	17,507	774,099	523,548	523,548
106	Mandimba	11,196	403,400	275,018	81,845	193,173	164,993	164,889
107	Marrupa	39,066	1,380,570	875,273	36,812	838,461	563,165	563,165
108	Maua	21,727	738,500	496,199	30,304	465,895	423,526	423,526
109	Mavago	26,734	878,875	558,774	11,496	547,278	11,506	10,507
110	Mecanhelas	9,889	407,616	285,434	86,575	198,859	145,258	116,628
111	Mecula	38,226	1,300,610	800,604	8,632	791,972	-82	-82
112	Metarica	13,567	467,481	308,177	17,454	290,723	261,129	261,129
113	Muembe	17,788	567,173	390,946	16,805	374,141	315,907	288,736
114	Ngauma	8,348	299,138	237,713	35,551	202,162	187,560	180,029
115	Nipepe	11,663	411,738	265,159	19,141	246,018	205,605	205,605
116	Sanga	32,715	1,096,130	626,097	35,506	590,591	386,086	339,959
201	Cidade_de_Pemba	32	1,847	1,813	112,842	-111,029	-111,029	-111,029
202	Ancuabe	11,682	410,982	330,887	67,813	263,074	114,457	114,457
203	Balama	11,346	504,048	389,629	77,514	312,115	237,900	237,900
204	Chiure	8,865	393,382	328,826	148,628	180,198	98,949	95,646
205	Ibo	157	4,636	3,317	5,203	-1,886	-3,929	-3,929
206	Macomia	10,508	383,013	315,692	55,386	260,306	88,682	80,812
207	Mecufi	2,437	81,211	69,211	27,157	42,054	34,632	32,309
208	Meluco	16,790	511,172	374,204	16,358	357,846	53,385	53,385
209	Mocimboa_da_praia	8,926	357,767	310,306	66,394	243,912	206,174	157,316
210	Montepuez	38,714	1,401,720	877,637	133,716	743,921	452,318	452,318
211	Mueda	27,362	923,436	583,716	79,663	504,053	286,026	285,580
212	Muidumbe	4,540	176,631	144,833	46,620	98,213	75,959	71,748
213	Namuno	9,439	393,929	313,130	110,059	203,071	128,356	128,356
214	Nangade	8,078	301,595	248,816	39,318	209,498	186,480	141,963
215	Palma	10,719	371,567	308,013	30,729	277,284	242,734	203,703
216	Pemba	3,577	111,483	97,278	38,141	59,137	-3,165	-3,855
217	Quissanga	5,332	173,746	153,730	23,110	130,620	-1,387	-1,387
301	Cidade de Nampula	357	16,493	16,493	391,368	-374,875	-374,875	-374,875
302	Angoche	5,145	215,015	181,662	203,478	-21,816	-43,078	-55,493
303	Erati	10,272	512,787	448,874	168,484	280,390	199,730	198,541
304	Cidade da Ilha de Mocambique	152	6,598	6,340	43,794	-37,454	-37,710	-37,807
305	Lalaua	7,526	282,336	238,793	46,252	192,541	130,609	118,253
306	Malema	12,282	446,062	361,133	110,392	250,741	168,069	138,441
307	Meconta	8,813	342,693	292,739	112,289	180,450	154,868	154,868
308	Mecuburi	14,445	575,873	468,654	108,748	359,906	162,662	162,662
309	Memba	10,809	447,799	401,946	149,913	252,033	219,618	214,494
310	Mogincual	13,455	499,898	430,302	69,630	360,672	341,017	330,134
311	Mogovolas	6,640	306,191	253,958	167,269	86,689	39,671	39,671
312	Moma	12,074	479,945	408,695	208,514	200,181	151,942	133,324
313	Monapo	11,314	441,870	385,306	196,313	188,993	171,965	171,940
314	Mossuril	10,508	363,283	317,990	78,737	239,253	215,578	199,282
315	Muecate	10,298	377,340	331,154	59,060	272,094	229,783	229,783
316	Murrupula	6,063	283,500	244,192	92,215	151,977	115,923	113,101
317	Cidade de Nacala-Porto	565	21,567	20,323	179,411	-159,088	-159,313	-159,395
318	Nacala-a-velha	3,175	133,095	119,766	59,716	60,050	55,101	53,146
319	Nacaroa	6,907	273,635	239,748	68,046	171,702	154,701	154,701

D_#	District	total Woody biomass stock 000 t	total non industrial increment t	available increment physically accessible t	residential and commercial consumption t	local balance t	commercial balance "liberal" t	commercial balance "conservative" t
320	Nampula	6,622	314,528	277,922	122,790	155,132	123,988	111,512
321	Ribaue	11,612	527,253	439,408	118,298	321,110	205,765	199,077
401	Cidade_de_Quelimane	165	6,333	6,017	169,907	-163,890	-163,890	-163,890
402	Alto_molocue	13,006	650,340	553,485	167,934	385,551	298,541	276,773
403	Chinde	4,862	191,154	137,601	83,209	54,392	6,285	-19,517
404	Gile	24,361	921,968	741,312	102,649	638,663	480,193	480,193
405	Gurue	8,835	410,268	331,253	214,948	116,305	-547	-10,431
406	Ile	10,855	491,518	416,889	178,907	237,982	182,724	182,433
407	Inhassunge	1,774	65,879	55,457	60,031	-4,574	-6,239	-26,573
408	Lugela	19,650	689,381	539,857	98,665	441,192	423,834	309,564
409	Maganja_da_costa	22,067	759,542	625,199	178,932	446,267	414,500	392,559
410	Milange	16,838	864,775	702,527	306,222	396,305	284,262	252,826
411	Mocuba	27,632	958,694	764,164	225,860	538,304	488,463	487,565
412	Mopeia	18,415	634,057	468,713	66,259	402,454	342,147	327,982
413	Morrumbala	33,183	1,258,920	1,009,480	216,781	792,699	542,703	527,603
414	Namacurra	3,579	166,748	141,474	115,778	25,696	1,764	-6,673
415	Namarroi	5,928	346,244	306,236	77,454	228,782	200,477	171,350
416	Nicoadala	7,554	269,732	213,692	147,098	66,594	48,400	26,974
417	Pebane	29,828	1,059,090	848,709	115,112	733,597	444,803	426,591
501	Cidade_de_Tete	157	8,362	7,984	128,613	-120,629	-120,656	-120,686
502	Angonia	5,323	260,025	77,568	211,155	-133,587	-138,696	-138,696
503	Cahora_bassa	10,241	417,252	234,249	57,466	176,783	50,286	42,726
504	Changara	13,778	597,260	403,206	95,619	307,587	179,876	173,249
505	Chifunde	19,001	752,824	558,071	53,887	504,184	383,633	280,782
506	Chiuta	12,693	482,303	316,484	43,803	272,681	169,723	121,774
507	Macanga	17,635	727,568	503,167	57,126	446,041	366,401	206,192
508	Magoe	7,958	334,000	177,872	39,164	138,708	44,370	41,332
509	Maravia	32,046	1,265,530	906,161	47,808	858,353	691,954	578,361
510	Moatize	12,170	522,660	329,259	126,120	203,139	58,586	50,598
511	Mutarara	8,859	353,552	54,043	122,634	-68,592	-89,205	-89,255
512	Tsangano	6,913	282,862	63,862	98,192	-34,330	-52,441	-52,448
513	Zumbu	22,680	871,336	555,718	32,126	523,592	377,068	331,189
601	Cidade_de_Chimoio	110	7,270	7,429	205,079	-197,650	-197,650	-197,650
602	Barue	14,536	614,773	487,115	87,342	399,773	318,116	245,266
603	Gondola	13,645	587,942	482,988	165,930	317,058	273,310	264,427
604	Guro	16,171	591,107	491,651	37,732	453,919	329,090	328,752
605	Machaze	29,277	1,189,130	891,061	62,919	828,142	479,619	478,252
606	Macossa	26,116	919,489	664,303	14,707	649,596	202,069	202,069
607	Manica	8,507	364,697	294,453	146,921	147,532	75,604	70,333
608	Mossurize	8,638	484,469	388,456	112,629	275,827	172,273	167,463
609	Sussundenga	18,813	760,332	631,902	77,863	554,039	305,363	290,005
610	Tambara	8,942	323,721	254,911	26,234	228,677	39,603	36,186
701	Cidade Da Beira	603	26,089	21,702	401,640	-379,938	-379,954	-379,967
702	Buzi	12,847	549,606	434,134	106,970	327,164	281,092	254,321
703	Caia	5,135	182,062	139,962	73,853	66,109	-16,277	-19,105
704	Chemba	6,478	263,607	230,140	39,962	190,178	106,014	101,022
705	Cheringoma	15,678	563,963	416,231	20,181	396,050	175,516	174,388
706	Chibabava	14,255	620,402	513,707	61,109	452,598	357,530	354,863
707	Dondo	3,229	129,098	91,605	109,321	-17,716	-49,249	-52,271
708	Gorongosa	14,013	545,417	433,090	73,155	359,935	178,952	178,637
709	Machanga	10,618	379,396	303,763	32,989	270,774	9,638	-2,291
710	Maringue	11,972	407,840	350,815	45,922	304,893	89,002	87,790

D_#	District	total Woody biomass stock 000 t	total non industrial increment t	available increment physically accessible t	residential and commercial consumption t	local balance t	commercial balance "liberal" t	commercial balance "conservative" t
711	Marromeu	10,877	407,514	265,119	75,062	190,057	-1,858	-18,659
712	Muanza	15,870	578,028	375,762	14,360	361,402	205,634	205,634
713	Nhamatanda	4,922	212,765	176,729	129,568	47,161	17,135	4,962
801	Cidade_de_Inhambane	184	8,441	8,184	56,278	-48,093	-48,919	-48,919
802	Funhalouro	34,520	1,087,280	855,009	23,959	831,050	704,115	514,037
803	Govuro	7,499	273,333	236,108	22,859	213,249	180,081	169,023
804	Homoine	1,600	83,258	75,910	71,629	4,281	-17,254	-21,410
805	Inharrime	4,874	180,477	163,359	62,824	100,535	59,388	2,350
806	Inhassoro	7,481	341,428	296,273	32,776	263,497	181,400	166,003
807	Jangamo	1,708	77,652	72,810	61,092	11,718	618	-1,706
808	Mabote	24,697	972,919	742,662	29,337	713,325	374,808	216,199
809	Massinga	16,230	791,896	702,572	130,233	572,339	470,694	459,592
810	Maxixe	309	16,520	15,915	94,668	-78,753	-79,321	-79,396
811	Morrumbene	4,743	240,989	214,292	85,379	128,913	88,500	78,393
812	Panda	10,256	404,286	339,506	32,262	307,244	199,225	70,953
813	Vilankulo	8,592	521,900	458,230	92,778	365,452	217,468	178,040
814	Zavala	2,766	126,995	113,656	93,886	19,770	-4,831	-5,965
901	Cidade_de_Xai-Xai	38	2,496	2,386	104,831	-102,445	-102,445	-102,445
902	Bilene	2,504	121,085	107,065	105,537	1,528	-21,852	-30,853
903	Chibuto	7,257	304,938	269,974	141,154	128,820	58,305	55,064
904	Chicualacuala	30,870	1,091,030	790,556	26,151	764,405	270,117	192,381
905	Chigubo	22,687	909,557	724,997	11,972	713,025	420,350	416,799
906	Chokwe	1,794	90,987	81,681	139,019	-57,338	-80,175	-91,323
907	Guija	6,672	250,215	201,304	48,043	153,261	108,741	90,214
908	Mabalane	15,107	531,124	347,171	19,962	327,209	156,184	142,106
909	Mandlakaze	4,431	194,541	171,278	116,819	54,459	6,420	-2,553
910	Massangena	11,279	453,999	381,186	9,888	371,298	186,681	184,574
911	Massingir	8,303	316,622	238,786	17,664	221,122	36,336	30,758
912	Xai-xai	1,768	78,008	65,866	121,802	-55,936	-62,019	-63,753
1,001	Cidade de Matola	226	11,385	13,786	551,554	-537,768	-537,768	-537,768
1,002	Boane	612	27,999	25,831	63,199	-37,367	-39,919	-40,106
1,003	Magude	9,463	415,812	361,052	43,182	317,870	162,567	147,742
1,004	Manhiça	2,874	117,898	105,297	101,914	3,383	-13,306	-28,951
1,005	Marracuene	535	26,471	22,922	70,955	-48,034	-50,013	-51,663
1,006	Matutuine	9,955	327,766	285,481	25,391	260,090	169,198	150,864
1,007	Moamba	5,759	248,251	227,845	39,179	188,666	94,987	86,845
1,008	Namaacha	2,040	91,376	81,847	28,143	53,704	10,585	10,415
1,101	Cidade de Maputo	2	153	153	39,137	-38,984	-38,984	-38,984
1,102	Cidade de Maputo	1	97	97	26,759	-26,662	-26,662	-26,662
1,103	Cidade de Maputo	1	124	124	35,497	-35,373	-35,373	-35,373
1,104	Cidade de Maputo	32	1,710	1,710	275,781	-274,071	-274,071	-274,071
1,105	Cidade de Maputo	9	827	827	115,956	-115,129	-115,129	-115,129
1,106	Cidade de Maputo	127	4,683	4,683	352,600	-347,917	-347,917	-347,917
1,107	Cidade de Maputo	66	3,563	3,563	135,979	-132,416	-132,416	-132,416