5 Wood energy scenarios in urban areas of East Africa and Southeast Asia

In this chapter woodfuel (fuelwood and charcoal) consumption in urban centres of selected countries of East Africa and Southeast Asia is analysed with the support of the Geographic Information System (GIS) data set produced by recent studies based on the WISDOM methodology in ten East and Central African countries (FAO, 2006b) and in the countries of Southeast Asia (FAO, in press).

Two levels of analysis are presented: a general overview of fuelwood and charcoal consumption in urban and rural areas, and the likely trends and case studies of spatial analysis of urban woodsheds, or areas of influence of woodfuel consumption, in selected African and Asian urban areas.

5.1 URBAN WOODFUEL CONSUMPTION IN EAST AFRICA AND SOUTHEAST ASIA IN 2000

The demand modules of WISDOM in East Africa and Southeast Asia were developed upon best estimates of national fuelwood and charcoal consumption. These reference values were chosen from national and international sources on the basis of the estimation methods (when reported) and on source competence/reliability. Country-level estimates were converted into per capita consumption levels in rural, rural village and urban contexts and then "spatialized" through population distribution maps (FAO, 2005b) with reference year 2000 and, for Southeast Asia only, 2015 (FAO, 2006b; FAO, in press).

Figures 16 and 17 show the marked difference between urban and rural areas with regard to fuelwood and charcoal consumption in the countries of East and Central Africa and Southeast Asia covered by the studies. In most of these countries there is a clear distinction between rural and urban woodfuel consumption patterns, which helps to understand and assess the major implications derived from the rapid processes of urbanization.

The exceptions to the general trend appear to be Eritrea and Thailand for which the most reliable references report a high charcoal consumption also in rural areas (FAO, 2006b; FAO, in press). In Yunnan Province, China, the consumption of charcoal is considered negligible (FAO, in press).

In addition to the clear dominance of charcoal in urban woodfuel consumption shown in the East African and Southeast Asian figures, it is probable that the rural fraction of charcoal consumption is in villages rather than in sparsely populated rural areas. Consequently, in these studies rural areas were further subdivided into rural settlements (more than 2 000 inhabitants/km^2) and sparsely populated areas (fewer than 2 000 inhabitants/km^2), with the assumption that in the first case, the land is occupied prevalently by housing, commercial buildings and infrastructures while, in the second, agricultural land uses prevail, as indicated by a study conducted by the International Institute for Applied Systems Analysis (IIASA) in China and Bangladesh (FAO, 2005b).

In rural settlements, woodfuel consumption was assumed to have a pattern somewhere between the urban and average rural levels, i.e. with higher charcoal and lower fuelwood consumption than in average rural conditions. Consumption in the sparsely populated rural areas was derived from the remaining "unallocated" consumption and resulted in a higher fuelwood and lower charcoal consumption than in average rural conditions (FAO, 2006b; FAO, in press).

5.1.1 Southeast Asian consumption scenarios, 2000–2015

As part of the Southeast Asian WISDOM study, woodfuel consumption in subregional urban and rural areas was projected to the year 2015, according to the national fuelwood and charcoal consumption trends shown by the GFPOS study and the business as usual (BAU) scenario (in which per capita consumption was kept stable and variations determined only by rural and urban population growth). These 2000–2015 consumption trends are shown in Figures 18 and 19. The reduction in woodfuel consumption predicted by the GFPOS study is clear, compared with the increase in the BAU scenario, and is primarily a result of the expected economic growth in Southeast Asia and consequent substitution of traditional fuels by "modern" ones such as LPG, kerosene and electricity. Nonetheless, even in an economically positive perspective the demand for

woodfuels will remain high in both the urban and rural context.

FIGURE 16
Urban and rural fuelwood and charcoal consumption in East African countries, 2000

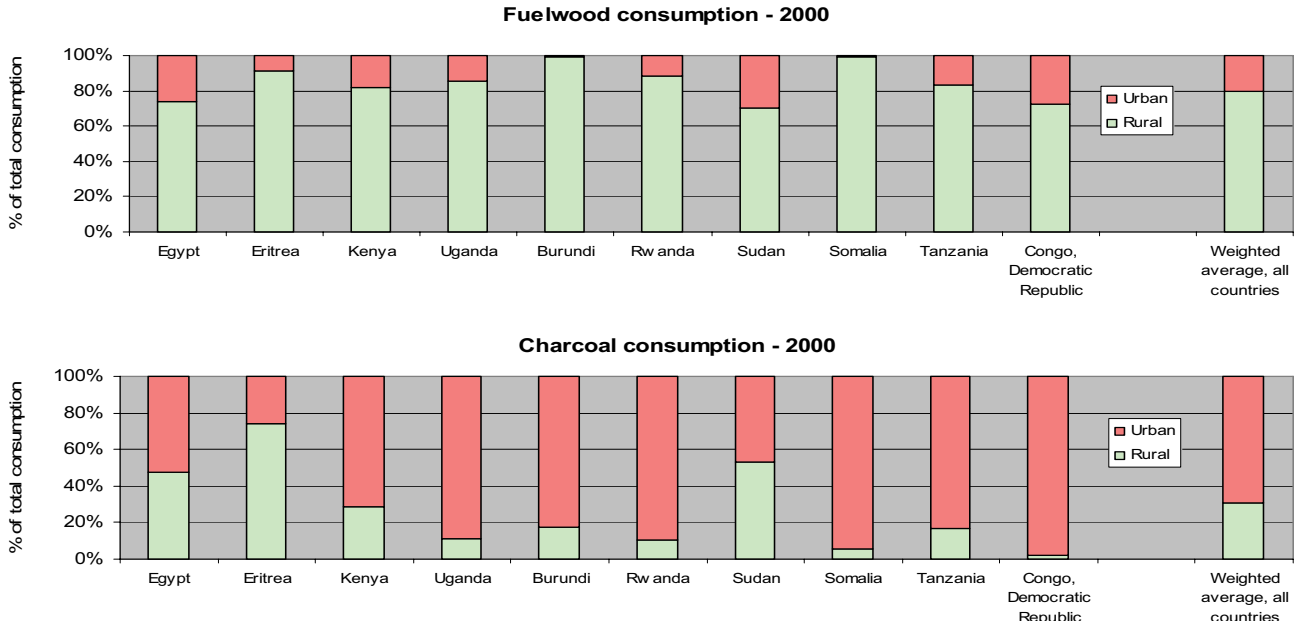


FIGURE 17
Urban and rural fuelwood and charcoal consumption in Southeast Asian countries, 2000

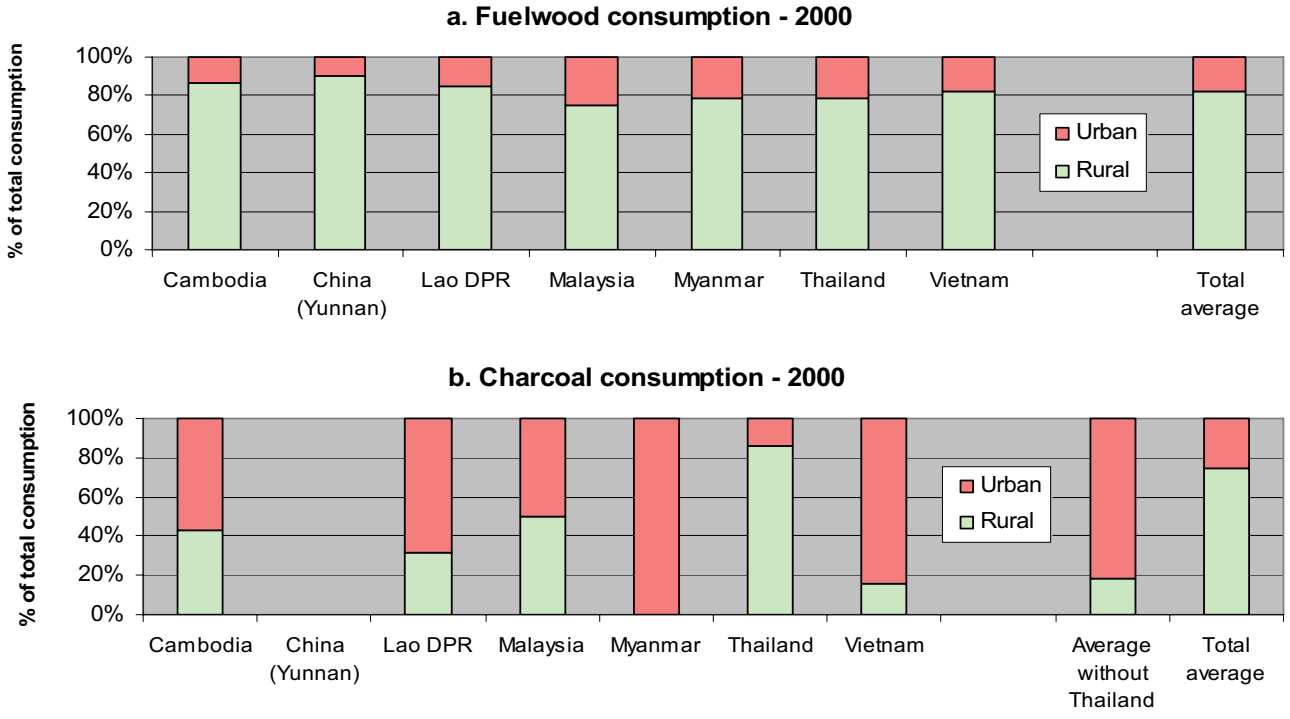
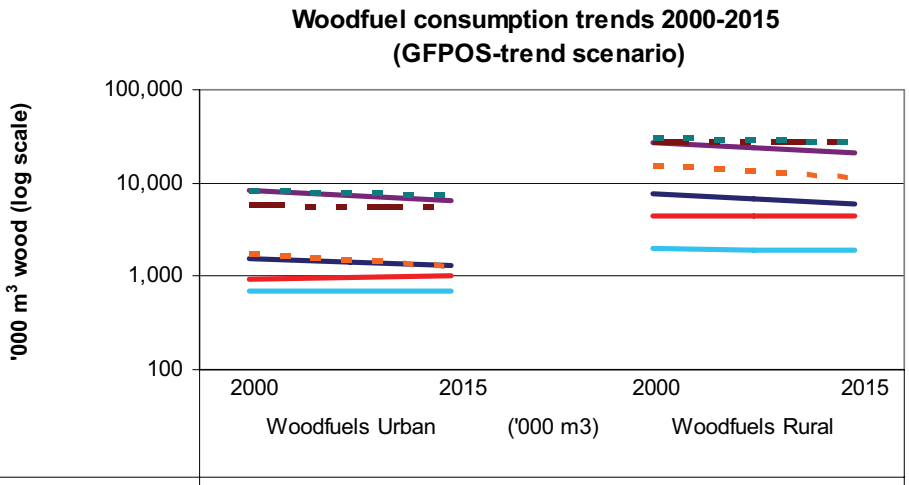
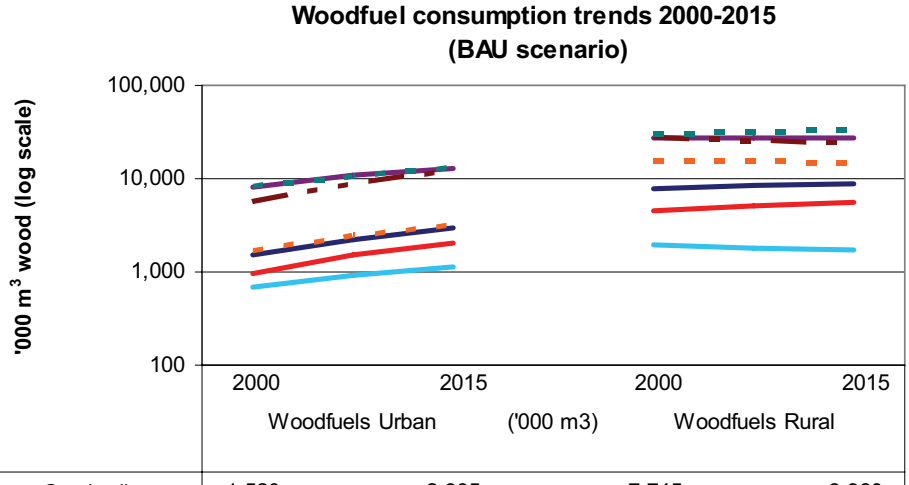


FIGURE 18
Woodfuel consumption trends in Southeast Asia (GFPOS scenario), 2000–2015



	Woodfuels Urban		Woodfuels Rural	
	2000	2015	2000	2015
Cambodia	1,520	1,307	7,745	5,927
China (Yunnan)	1,679	1,257	15,111	11,316
Lao DPR	952	1,003	4,501	4,508
Malaysia	696	688	1,961	1,886
Myanmar	8,282	6,533	26,902	21,372
Thailand	5,623	5,442	26,770	27,460
Vietnam	8,060	7,469	29,583	26,858

FIGURE 19
Woodfuel consumption trends in Southeast Asia (BAU scenario), 2000–2015



	Woodfuels Urban		Woodfuels Rural	
	2000	2015	2000	2015
Cambodia	1,520	2,935	7,745	8,960
China (Yunnan)	1,679	3,048	15,111	14,794
Lao DPR	952	2,037	4,501	5,558
Malaysia	696	1,115	1,961	1,700
Myanmar	8,282	13,021	26,902	26,866
Thailand	5,623	11,938	26,770	24,116
Vietnam	8,060	12,611	29,583	31,908

5.2 URBAN WOODSHED ANALYSIS OF SELECTED URBAN AREAS

In these paragraphs, the urban woodshed, or theoretical area of influence of fuelwood and charcoal consumption in selected urban areas, is analysed, based on estimated woody biomass production capacities and woodfuel consumption in the legally and physically accessible areas around cities.

The case studies analysed were all concerned with selected urban areas of East Africa and Southeast Asia in order to benefit from the recent WISDOM studies in these regions (FAO 2006b; FAO, in press). The geodatabases created for the regions, which provided spatially discrete parameters related to woodfuel consumption and production potential, as well as local-level supply/demand balance, provided an appropriate analytical setting for the delineation of hypothetical urban woodfuel supply zones.

5.2.1 Urban woodshed module of WISDOM studies in East Africa and Southeast Asia

As described briefly in Section 4.3.1, and depicted in Figure 15, the standard WISDOM methodology can be extended with an additional urban woodshed module designed for the analysis and delineation of the basin of provision of a preselected consumption site such as a single city of wide urban agglomerations. This additional phase necessitates a definition of the share of the local woodfuel productivity that may be suitable for a commercial circuit, plus a definition of resource accessibility from a legal and physical perspective. The following sections describe the conceptual and methodological steps undertaken in the analysis of urban woodsheds of selected locations in East Africa and Southeast Asia. Further details on the analysis procedure and reference data used are given in Annex 4.

Definitions of urban woodfuel supply zones

The area of influence or supply zone referring to the woodfuel consumption of a specific urban area was determined from diverse perspectives, each delimiting a different area. Two basic aspects were considered in the definition of theoretical supply zones – the supply sources of woody biomass (total and commercial only) and the inclusion, or otherwise, of local supply/demand balance in the estimation of resources available for urban consumption, as shown in Table 6.

TABLE 6
Definition matrix of urban woodfuel supply zones based on supply sources considered and estimation procedures

		Estimation elements	
		Woodfuel consumption in selected urban area only	**Woodfuel supply/demand balance within supply zone**
Woodfuel supply sources		**(restricted estimation system)**	**(expanded estimation system)**
All woodfuel sources	(“total” supply potential)	restricted-total	expanded-total
Woodfuel sources suitable for commercial production	(“commercial” supply potential)	restricted-commercial	expanded-commercial

The main distinction between the restricted and the expanded approach is that only urban woodfuel demand is considered in the first, while in the second the local supply/demand balance and therefore the demand outside the selected city is also taken into account. Consequently, in the expanded approach deficit cells around the selected urban area have the effect of further expanding the area of influence, which will “close” only when wood resources (total or commercial) are sufficient to balance the urban demand as well as other deficit areas around the city.

Listed by increasing area of influence, the definitions given below were adopted.

Restricted total supply zone. This is the area around the city where the total potential sustainable and accessible woodfuel production capacity equals the woodfuel consumption of the city itself. All woody

biomass productivity is accounted for, including that of sparse and degraded vegetation types and farmlands. Woodfuel consumption outside the city is not considered.

Restricted commercial supply zone. This is the area around the city where the potential sustainable, accessible and economically viable woodfuel production capacity equals the woodfuel consumption of the city itself. Only the woody biomass productivity of denser forest and woodland formations is accounted for, since sparse and fragmented formations are not suitable for commercial fuelwood and charcoal production. Woodfuel consumption outside the city is not considered.

Expanded total supply zone (based on local balance and total surplus). This is the area around the city in which the balance between total woodfuel demand and supply (from all biomass sources) achieves stability. Consumption outside the city is taken into account. The estimation procedure is two-phase.

1. The supply/demand balance is estimated at the local level, i.e. within cells of 10 x 10 km, in which all accessible wood productivity is considered.
2. The area around the city is progressively expanded until total demand (counting not only the city but also all consumption from urban and rural areas progressively included) is counterbalanced by total productivity.

Expanded commercial supply zone (based on local balance and commercial surplus). This is the area around the city in which the balance between total woodfuel demand and "commercial" supply achieves stability. Consumption outside the city is taken into account but the surplus woody biomass (local productivity higher than local consumption) is limited to the "commercial" share, i.e. derived from dense forest and woodland formation. The estimation procedure is three-phase.

1. The supply/demand balance is estimated at the local level, i.e. within cells of 10 x 10 km, in which all accessible wood productivity is considered. The result is a countrywide map of deficit and surplus areas.
2. Surplus areas are reviewed in relation to the "commercial" or "non-commercial" character of surplus resources, depending on the density of forests and woodlands. The result is a countrywide map of "commercial" surplus potentially available and economically accessible for urban woodfuel markets.
3. The area around the city is progressively expanded until total demand (counting not only the city but also all consumption from urban and rural areas progressively included) is counterbalanced by "commercial" surplus.

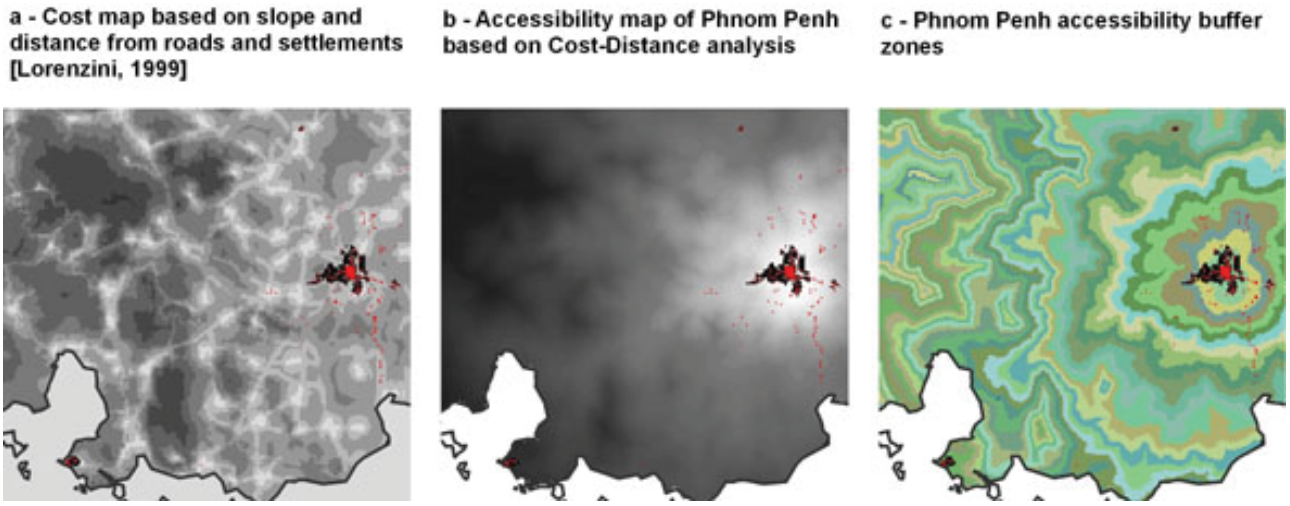
The idea of determining four different and progressively increasing supply zones is to show the complex and far-reaching urban/rural interface in both geographic and socio-economic terms. It is definitely not recommended that the role and impact of cities be analysed without an understanding of the human and environmental context as a whole, including both urban and rural environments.

Accessibility

The issue of physical accessibility, which was largely neglected in the WISDOM studies on East Africa and Southeast Asia because of the focus on local supply/demand situations, acquires particular relevance in urban wood energy systems where the transportation of fuelwood and charcoal has an essential role.

In order to visualize the main methodological steps in the present study, the accessibility of potential woodfuel resources from selected urban areas was determined by cost maps (Figure 20a), based on slope and distance from roads and settlements (Lorenzini, 1999a, pers. com.); the production procedure is described in Annex 3. Country-level cost maps were then used to determine accessibility buffers around selected urban centres (Figure 20b, c) within which woodfuel consumption and potential accessible supply were analysed, as described in Annex 4.

FIGURE 20
Example of accessibility mapping from cost map to accessibility buffers in Cambodia (Phnom Penh as urban area of cost-distance calculation)



Note: These maps show only the elements of physical accessibility. Legal accessibility factors, such as protected areas with limited access rights are not shown, although included in the estimation of resources actually accessible.

The accessibility buffers delineated in the study were based on relatively coarse digital elevation data[7] and on rather outdated maps of roads and settlements,[8] all available at the global level. Although useful for preliminary analyses they would be inadequate for local operational studies for which detailed and up-to-date information on actual transportation networks and economic evaluation of transportation costs are essential.

Urban woodshed analysis in selected East African locations

Analysis of urban woodsheds for selected urban areas in East Africa was based on digital thematic maps and statistics produced as part of the East African WISDOM study.

The reference year of the study, determined by demographic and land cover reference data, was 2000. The spatial resolution of the supply module, based on Land Cover Classification System (LCCS) maps, was relatively high, with original scales between 1:100 000 and 1:200 000. The resolution of local supply/demand balance analysis (integration module) was much lower, i.e. 5 arc-min cell size or 9.2 x 9.2 km at the equator.

The cities, selected arbitrarily to exemplify urban woodshed analyses, included Dar-es-Salaam and Arusha-Moshi in the United Republic of Tanzania; Kampala in Uganda; and Khartoum in the Sudan.

The features and methodological background of the East African WISDOM study are given in the published documentation (FAO, 2006b). The analytical work on the definition and mapping of urban woodsheds is shown in Figure 21 and described in greater detail in Annex 4.

The thematic maps resulting from these analyses are discussed in Section 5.3.2.

Urban woodshed analysis in selected Southeast Asian locations

The methodology of analysis for the Southeast Asian WISDOM data set was similar to that applied for East Africa, apart from the following aspects.

- The spatial resolution of the Southeast Asian WISDOM study was 30 arc-sec, i.e. 0.92 x 0.92 km at the equator (rather than 5 arc-min).
- Legal accessibility factors were already accounted for in the original WISDOM study.
- The original study included an analysis for the year 2000 as well as for 2015, giving several

[7] Global 30 arc-sec GTOPO30 digital elevation model of the Eros Data Center (1997).
[8] Digital Chart of the World. version 1999, which reported road networks and settlements in the late 1980s.

supply/demand scenarios. This meant that probable evolutions of urban woodsheds to 2015 could be analysed (limited to the Phnom Penh case study).

- Subnational maps of malnutrition indicators estimated for the year 2000 (mainly stunting growth in children under five) enabled the nutritional conditions of the population living within the urban woodshed areas to be analysed, as a proxy for poverty conditions.

The analytical work on the definition and mapping of urban woodsheds for the selected Southeast Asian study sites presented several differences compared with those in East Africa. The analytical steps are shown in Figure 22 and described in greater detail in Annex 4.

The cities selected for urban woodshed analyses were Phnom Penh and Battambang in Cambodia; and Vientiane and Luang Prabang in the Lao People's Democratic Republic.

The urban woodshed maps resulting from the analyses of these sites are discussed in Section 5.3.1.

FIGURE 21
Flow chart of main analytical steps, East African WISDOM data set
(resolution = 5 arc-min, i.e. 9.2 x 9.2 km at the equator)

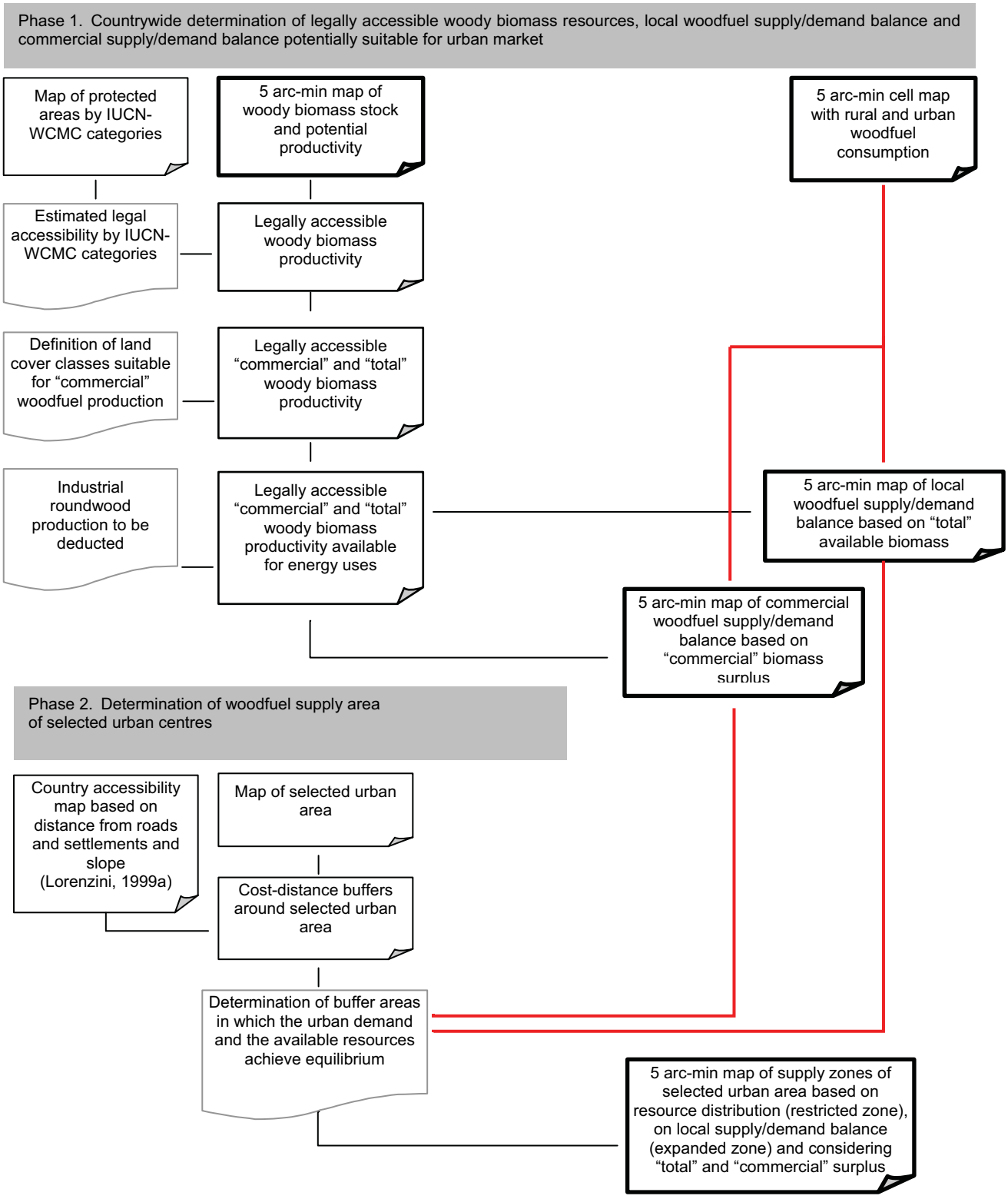
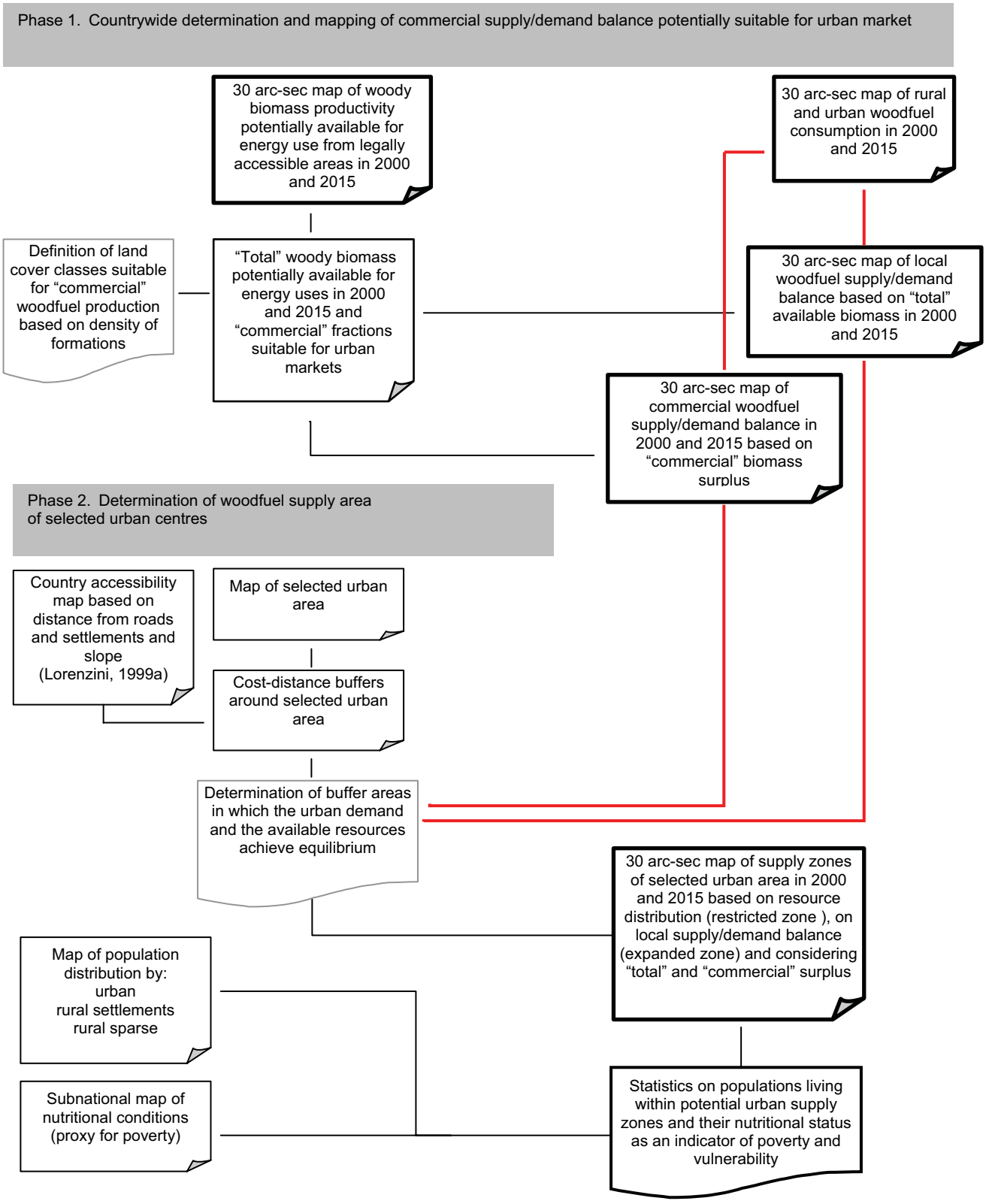


FIGURE 22
Flow chart of main analytical steps, Southeast Asian WISDOM data set
(resolution = 30 arc-sec, i.e. 0.92 x 0.92 km at the equator)



5.2.2 Data limitations

Regional analysis based on global and regional data sets may present several inaccuracies when observed at the local level, as in the case of urban woodshed analysis, because of the relatively coarse resolution of reference maps. Such approximations concern the following.

- Spatial population maps and consequent spatialization of woodfuel consumption, as a result of the population distribution algorithms, which are particularly weak in Africa (FAO, 2005b); in addition, population data within 5 arc-min cells present major problems along coastal areas of the East African data set (it is therefore recommended that the analysis at the original 30 arc-sec resolution be reviewed in order to avoid the coastal area problem).
- Woody biomass distribution and productivity, resulting from coarse land cover maps (as for Southeast Asia) and limited field measurements of volume and productivity, especially for open and degraded forest formation and non-forest woody biomass sources.
- Quantity and sources of wood assortments used by timber industries and other non-energy applications; in the present study total industrial roundwood was assumed to come from dense formations (the same sources assumed suitable for commercial woodfuel production). A more precise identification of industrial wood sources would enhance the definition and location of woody biomass actually available for energy uses (see Annex 4).
- Definition of "commercial" woodfuel sources; these were tentatively defined from land cover class descriptions and limited to woody formations with high density, assuming that they would be more suitable for charcoal and fuelwood production from a commercial perspective (see Annex 4).
- Per capita consumption rates in urban areas, rural settlements and sparse rural areas, which were often inferred because of limited and contradictory reference data.
- Accessibility ranking, which was based on relatively coarse terrain models and probably outdated road network and settlement maps (see Annex 3).
- Several other assumptions concerning the commercial versus non-commercial woodfuel sources, identification of industrial roundwood sources, limited access within protected areas, etc.

The mapping of urban woodsheds presented in the following section was carried out by segmentation of the territory according to accessibility buffers, and the limit of a supply zone was determined by the buffer whereby the cumulative supply exceeded consumption. Consequently, the limits of the supply zones are not the exact place where the "non-negative" balance condition was achieved but rather that of the buffer within which such condition occurred. It is useful to bear this in mind with regard to the summary woodshed statistics.

The examples should be considered as "first-level" delineations meant to provide a visual support to the methodological discussion rather than as accurate woodshed analyses. Regional and national-level analyses can best express their potential in the preliminary phase of urban woodshed analysis by providing i) a comprehensive overview; ii) a rapid delineation of specific woodsheds; and iii) an objective definition of priority areas for operational action in which additional investment in data collection and analysis may be justified and cost effective.

5.3 SELECTED URBAN WOODSHED ANALYSES: RESULTS AND FINDINGS

The following maps depict the supply zones of selected urban centres in East Africa and Southeast Asia delineated according to total and commercial supply potential (restricted zones) and to estimated surplus resources after deduction of local woodfuel demand (expanded zones).

The cities, selected arbitrarily to exemplify urban woodshed analyses, in Southeast Asia were those of Phnom Penh and Battambang in Cambodia; and Vientiane and Luang Prabang in the Lao People's Democratic Republic. In East Africa, they were Dar-es-Salaam and Arusha-Moshi in the United Republic of Tanzania; Kampala in Uganda; and Khartoum in the Sudan.

In order to exemplify the analysis methodology, the Southeast Asian woodsheds are presented first because the baseline data available for this subregion allowed the inclusion of additional elements related to poverty and to the possible evolution of the situation to 2015, elements that were not available for East Africa.

5.3.1 Selected Southeast Asian urban woodsheds

Phnom Penh, Cambodia, 2000

Figure 23 shows the delineation of the restricted woodshed supply zones, with the background of the relevant woody biomass resources. The top map shows the restricted-total supply zone, which is the area necessary for providing the amount of woodfuel consumed in Phnom Penh on account of sustainable woody biomass productivity (available for energy use) from all sources and according to accessibility determined by roads, settlements and slope.

The bottom map shows the restricted-commercial supply zone and considers only consumption in Phnom Penh city. On the supply side it relates only to the sustainable productivity of dense forest and woodland formations considered more suitable for commercial woodfuel production for urban markets. The difference between these two zones is great, because woody biomass resources in the proximity of the city are mostly composed of open, fragmented and degraded formations and trees outside forest in agricultural landscapes, as was deduced from the land cover map used in the regional WISDOM analysis. These resources play an important role in the local context but may be uneconomic from a commercial perspective.

Figure 24 shows the delineation of the expanded supply zones, with the background of the relevant woodfuel supply/demand balance data. The delineation of the supply zones in these cases took into account not only consumption in Phnom Penh but also that of the other areas progressively included until the overall equilibrium between demand and supply was achieved.

The top map shows the expanded-total supply zone, which took into consideration the entire local surplus (shaded green) from all possible sources, including sparse and fragmented areas.

The bottom map shows the expanded-commercial supply zone, and considers only the surplus from denser formations more suitable for commercial woodfuel production for distant urban markets. The commercial balance map, background to the second image, shows the same deficit areas (shaded red) as the first but with a smaller surplus area (shaded green) and a greater "balanced" area, because of the exclusion of those resources that, although important in a localized supply/demand context, are less significant for the provision of distant cities.

With an urban population of approximately one million, Phnom Penh influences the environment and socio-economics of a considerable part of the national territory. As shown in Table 7, the different Phnom Penh supply zones range from some 14 000 km^2, home to 4.7 million people, to over 70 000 km^2 and 10 million people. Of particular relevance from the perspective of sustainable development and poverty alleviation, these zones include numerous communities, here accounted for under sparse rural population, which could be the major beneficiaries of sustainable wood energy systems created to provide woodfuels for cities and other large settlements. Their number varies between 1.6 million for the restricted-total zone to some 5.5 million for the expanded-commercial one.

FIGURE 23
Phnom Penh restricted woodshed zones

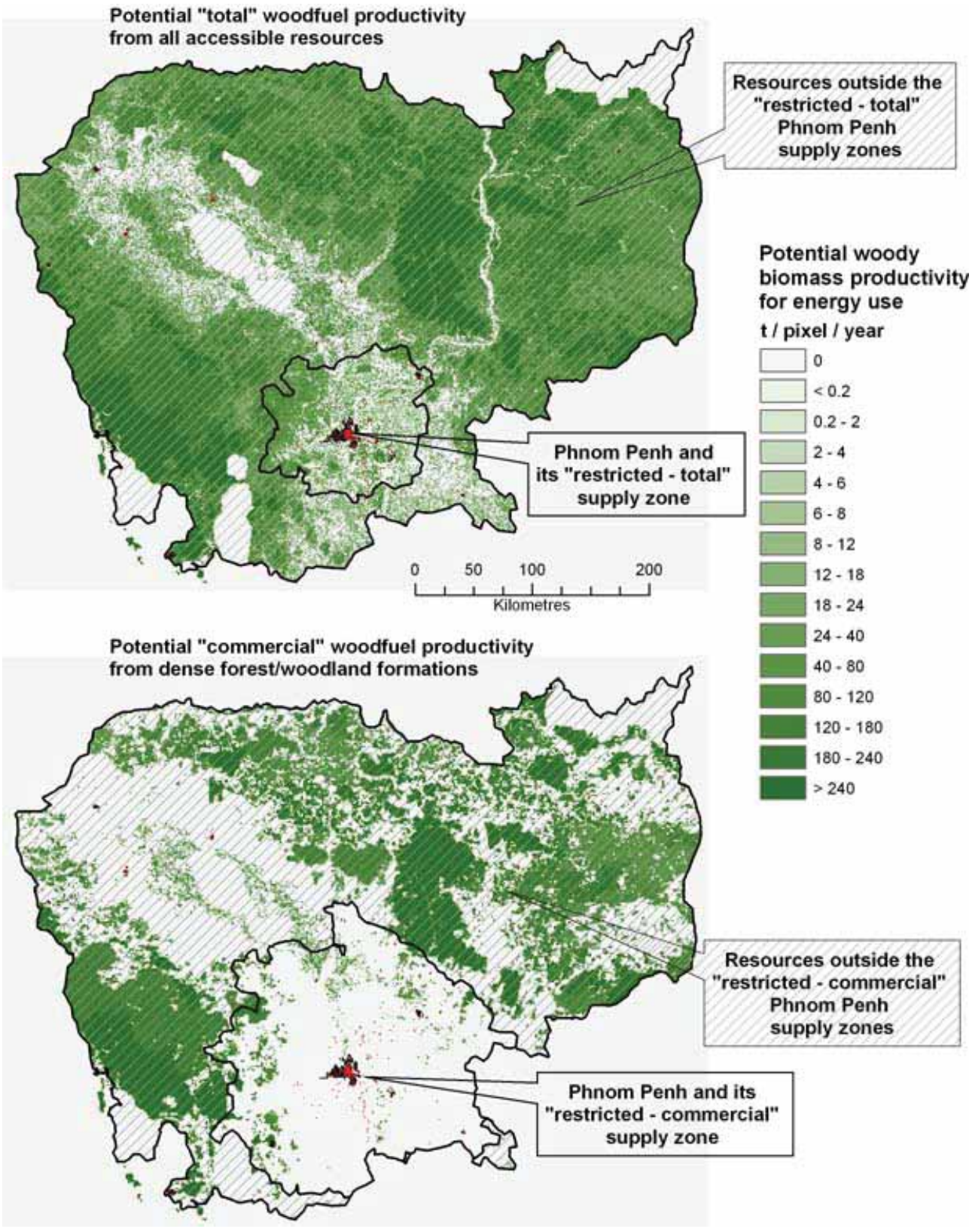


FIGURE 24
Phnom Penh expanded woodshed zones

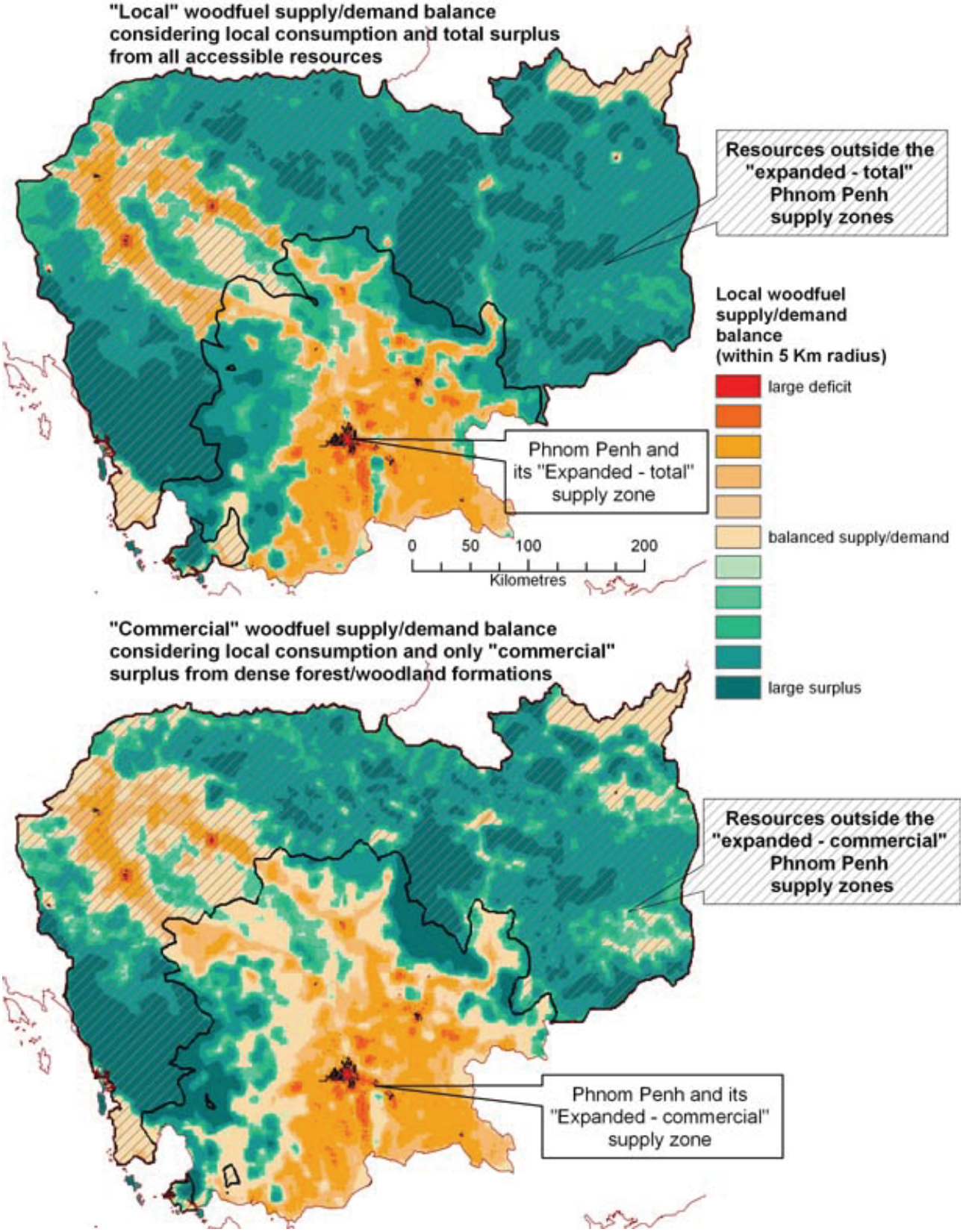


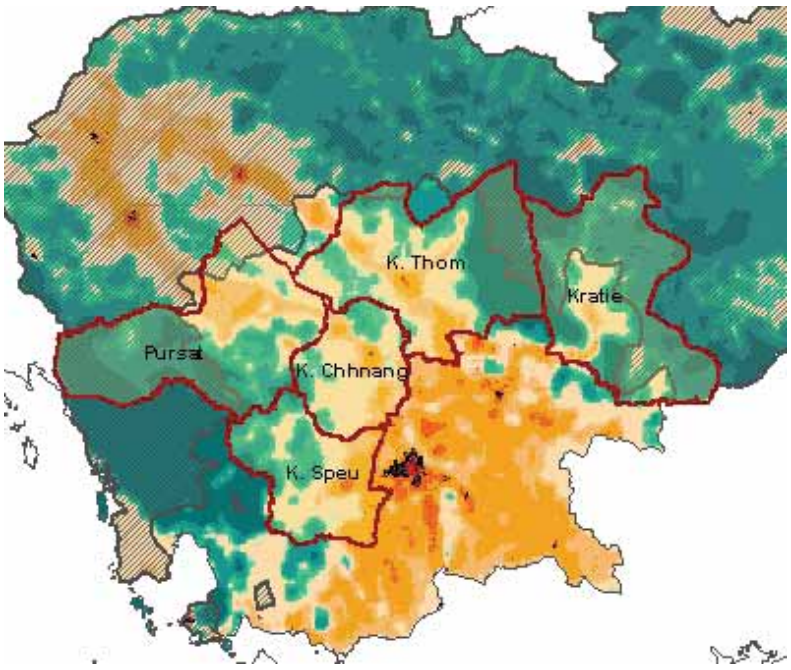
TABLE 7
Main statistics for Phnom Penh woodshed zones

		Phnom Penh supply zones			
		Restricted		Expanded	
		Total	Commercial	Total	Commercial
Area of supply zone	km^2	13 900	39 900	60 100	70 400
Annual consumption (2000)	$t*yr^{-1}$	461 300	461 300	4 012 600	4 185 500
Potential annual supply or surplus	$t*yr^{-1}$	514 600	552 200	4 282 400	4 288 700
Population ('000 inhabitants)					
Urban		1 856	1 975	1 999	1 999
Rural settlements		1 223	2 445	2 655	2 672
Sparse rural		1 613	4 128	5 132	5 461
Total population		4 693	8 548	9 786	10 131

The results of the Phnom Penh urban woodshed are supported by the study carried out in 1998 on the city's woodfuel flow in the framework of the Regional Wood Energy Development Programme in Asia (FAO, 1998b). According to this study, fuelwood and charcoal come from forested areas in Kratie, Kampong Thom, Kampong Speu, Pursat and Kampong Chhnang. As shown in Figure 25, these provinces overlap with the expanded-commercial supply zone estimated for the year 2000.

The study reports that, since 1970, forested areas have been greatly reduced because of war, agricultural clearance, construction and logging concessions. Communities within the supply areas reported that forest loss and degradation have been most rapid over the last few years, and the reasons given for this include agricultural clearance and firewood collection. The provision of wood energy is often associated with forest loss, but involvement in the wood energy trade is often a secondary factor and cutting trees to obtain land for agricultural use is the primary factor (FAO, 1998b).

FIGURE 25
Provinces supplying woodfuels to Phnom Penh (expanded-commercial woodshed in the background)



In addition, confirming the need to differentiate between local and commercial woodfuel sources, the study reports that within rural areas, most wood for local consumption is collected from agricultural land, such as paddy dykes, which suggests that the supply for commercial urban markets has the greatest impact on forests. A main issue in these areas is that of landownership, since it is mainly those without land who are engaged in the trade (FAO, 1998b).

Phnom Penh to the year 2015

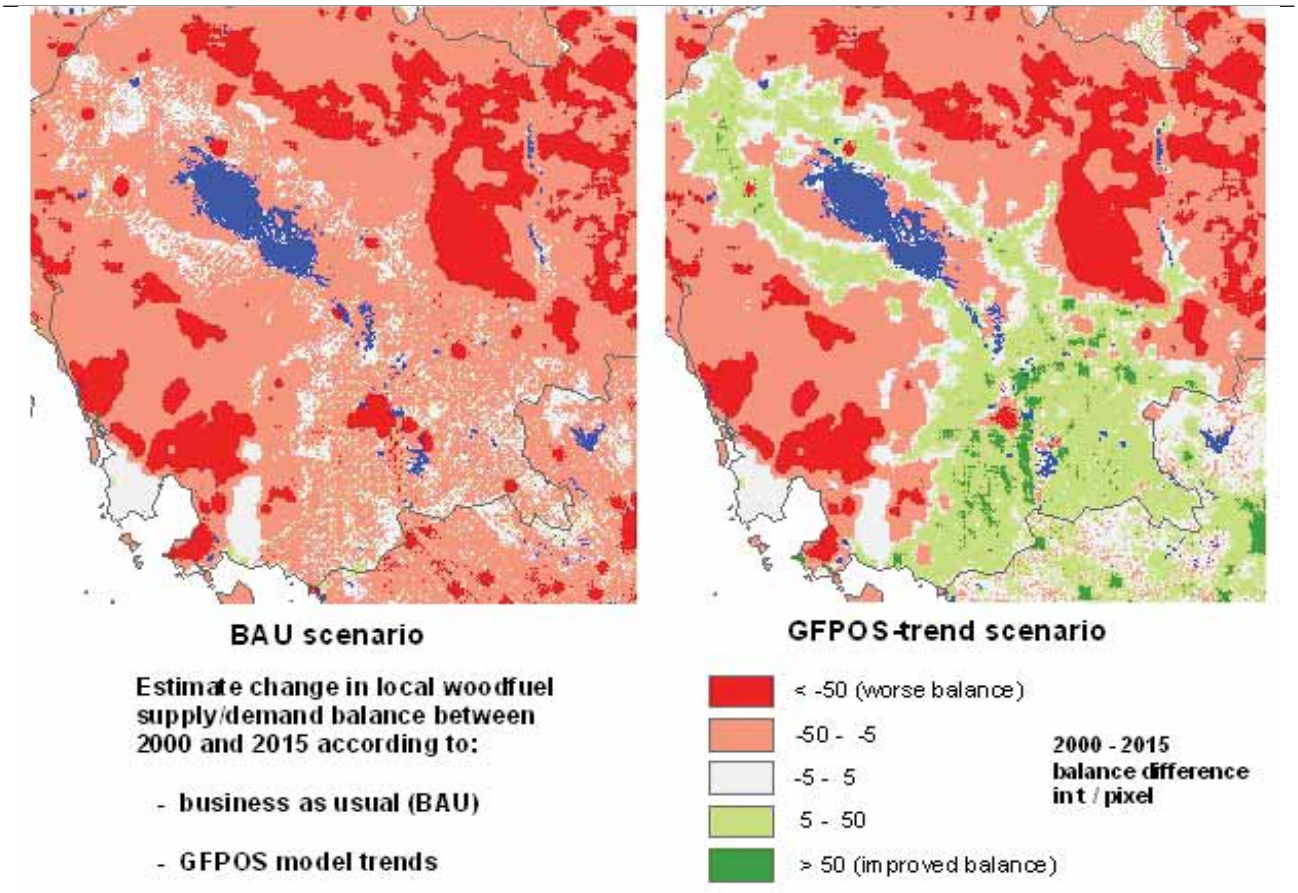
The possible evolution of the Phnom Penh woodshed to the year 2015 was tentatively outlined on the basis of the 2015 woodfuel supply/demand balance predicted in the Southeast Asian WISDOM study using spatialized population projections and land cover change rates (FAO, in press).

The changes in supply/demand balance over the period 2000–2015 according to both the BAU and the GFPOS scenario are shown in Figure 26. While the BAU scenario depicts a homogeneous negative trend

simply as a result of population growth, the GFPOS scenario offers a more composite situation resulting from expected economic growth and fuel substitution trends.

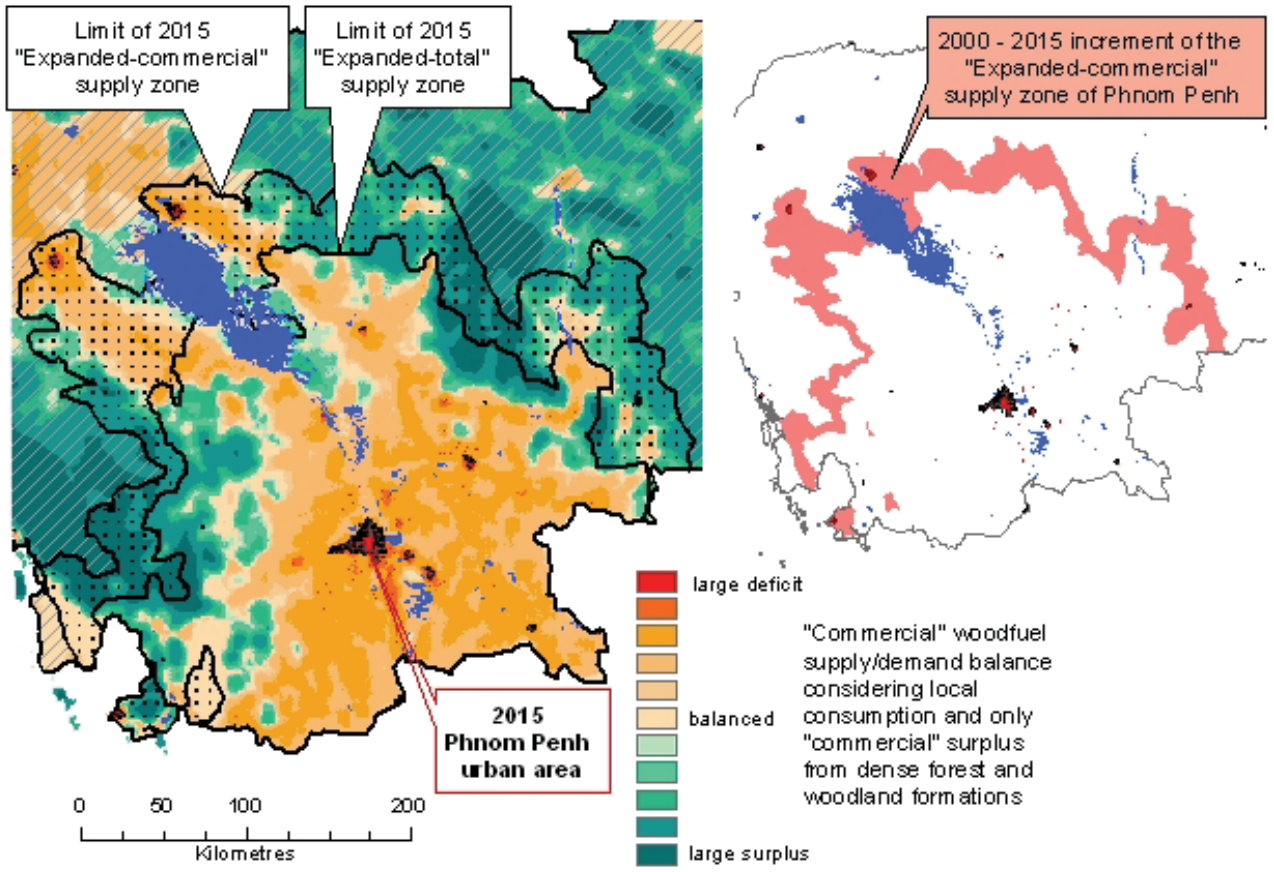
The woodshed evolution in 2015 was based on the GFPOS scenario, which appears more realistic and optimistic than that of BAU.

FIGURE 26
Projected woodfuel supply/demand balance in 2015 and possible changes with regard to the 2000 baseline balance



The results of the 2015 projection are shown in Figure 27, which gives the limits of the expanded-commercial and expanded-total supply zones as well as the net increment of the former in the period 2000–2015. In spite of the overall reduction in woodfuel demand predicted by the GFPOS model, there is a significant increase in supply in the expanded-commercial zone, which may be explained by the relative increase in charcoal consumption in urban areas and the projected deforestation rates, with consequent reduction in dense forest formations that are sources of “commercial” biomass.

FIGURE 27
Phnom Penh expanded woodshed zones in 2015 (GFPOS-trend scenario) and 2000–2015 woodshed area expansion



Battambang, Cambodia

The woodshed analysis for Battambang, the second-largest city in Cambodia, resulted in the supply zones shown in Figure 28. Here the four zones were overlaid on the estimated woody biomass productivity (restricted zones) and the commercial balance (expanded zones).

The urban woodshed areas of Battambang are far less extensive than Phnom Penh, primarily because of the smaller size of the city. Here the area of the restricted-commercial supply zone is roughly equal to the expanded-total supply zone, since the reduction in local consumption of the expanded zone is offset by the non-commercial supply sources.

The main statistics of the supply zones are summarized in Table 8. In Battambang, the sparse rural population located within the area of influence and potentially involved in woodfuel production varies between 0.4 and 1.8 million, depending on the supply zone considered. However, the expanded zones, which account also for local consumption outside the city, are much more realistic. What appears difficult to determine, given the lack of field data, is the distinction between the woody biomass used exclusively for local consumption and that suitable for commercial woodfuel production, which establishes the size of the expanded-commercial zone.

FIGURE 28
Battambang woodshed zones

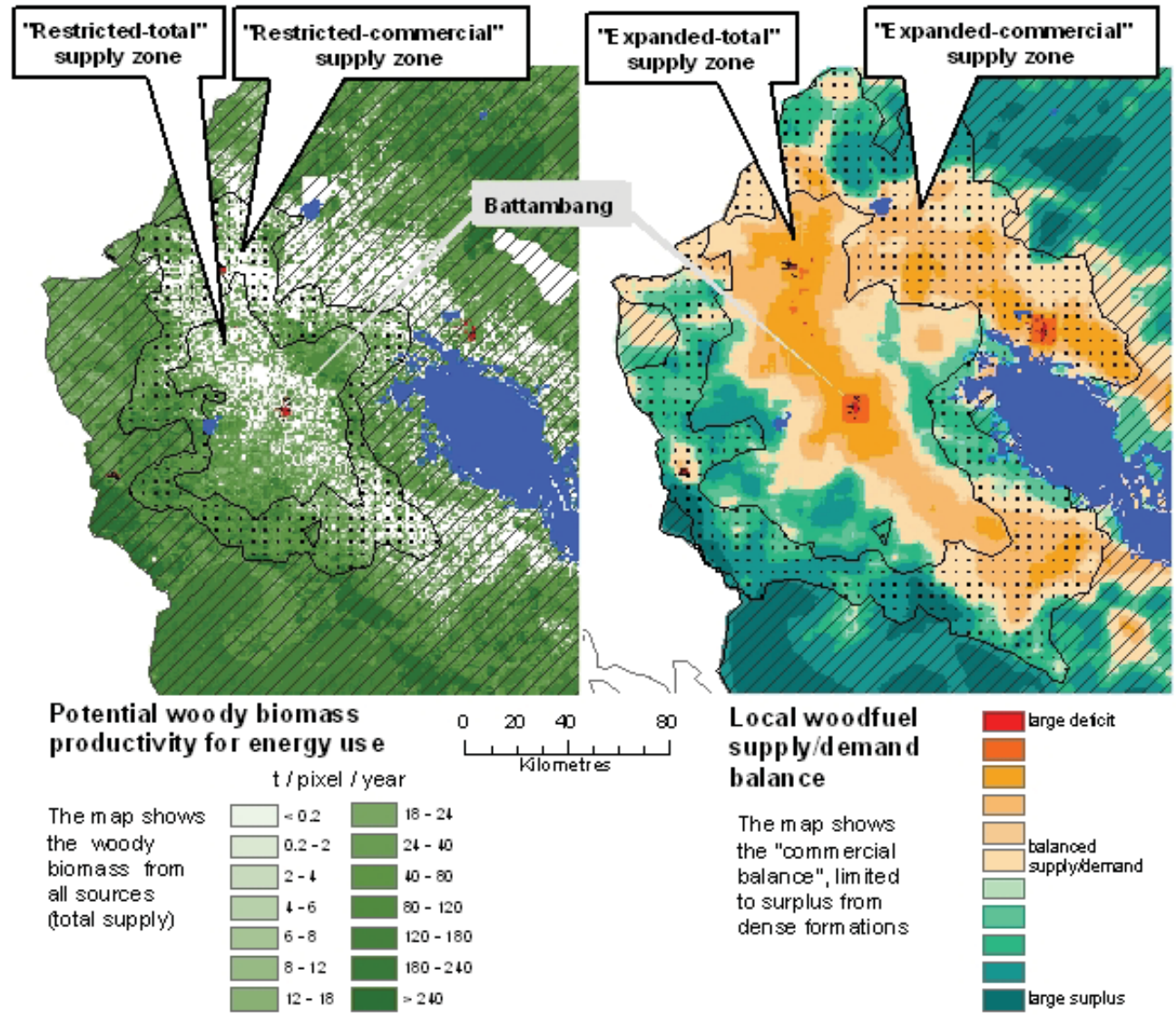


TABLE 8
Main statistics for Battambang woodshed areas

		Battambang supply zones			
		Restricted		Expanded	
		Total	Commercial	Total	Commercial
Area of supply zone	km^2	4 200	10 900	10 900	27 500
Annual consumption (2000)	$t*yr^{-1}$	125 000	125 000	416 000	546 000
Potential annual supply or surplus	$t*yr^{-1}$	185 000	214 000	457 000	635 000
Population ('000 inhabitants)					
Urban		91	116	116	232
Rural settlements		262	334	334	440
Sparse rural		431	861	861	1 843
Total population		784	1 311	1 311	2 515

The expanded-commercial zones of Phnom Penh and Battambang overlap each other over a limited area, as visible in Figure 29. This means that the potential supply for each city in this area is reduced and that the entire supply zone of each city should be increased accordingly.

Nutritional conditions within the Phnom Penh and Battambang woodsheds

As discussed previously, the relation between poverty and wood energy is multifold, with important implications not only for urban and rural users but also for woodfuel producers, who may depend on wood energy systems for their livelihoods. From this perspective, the establishment of sustainable urban wood energy systems may have considerable sustainable development and poverty alleviation effects for decentralized rural communities.

Mapping poverty is an ongoing challenging task and a comprehensive thematic map is not yet available (FAO, 2002c; 2003d). The main poverty-related spatial data set available at the time of analysis was an indicator of malnutrition, i.e. a map of the incidence of stunt growth in children under five, as a percentage, by subnational administrative units (FAO, in press). This parameter is one of the best indicators of poverty, as indicated by WHO. The incidence of stunting within the Phnom Penh and Battambang woodsheds is shown in Figure 29 and summarized in Table 9.

FIGURE 29
Nutritional conditions within the Phnom Penh and Battambang woodsheds

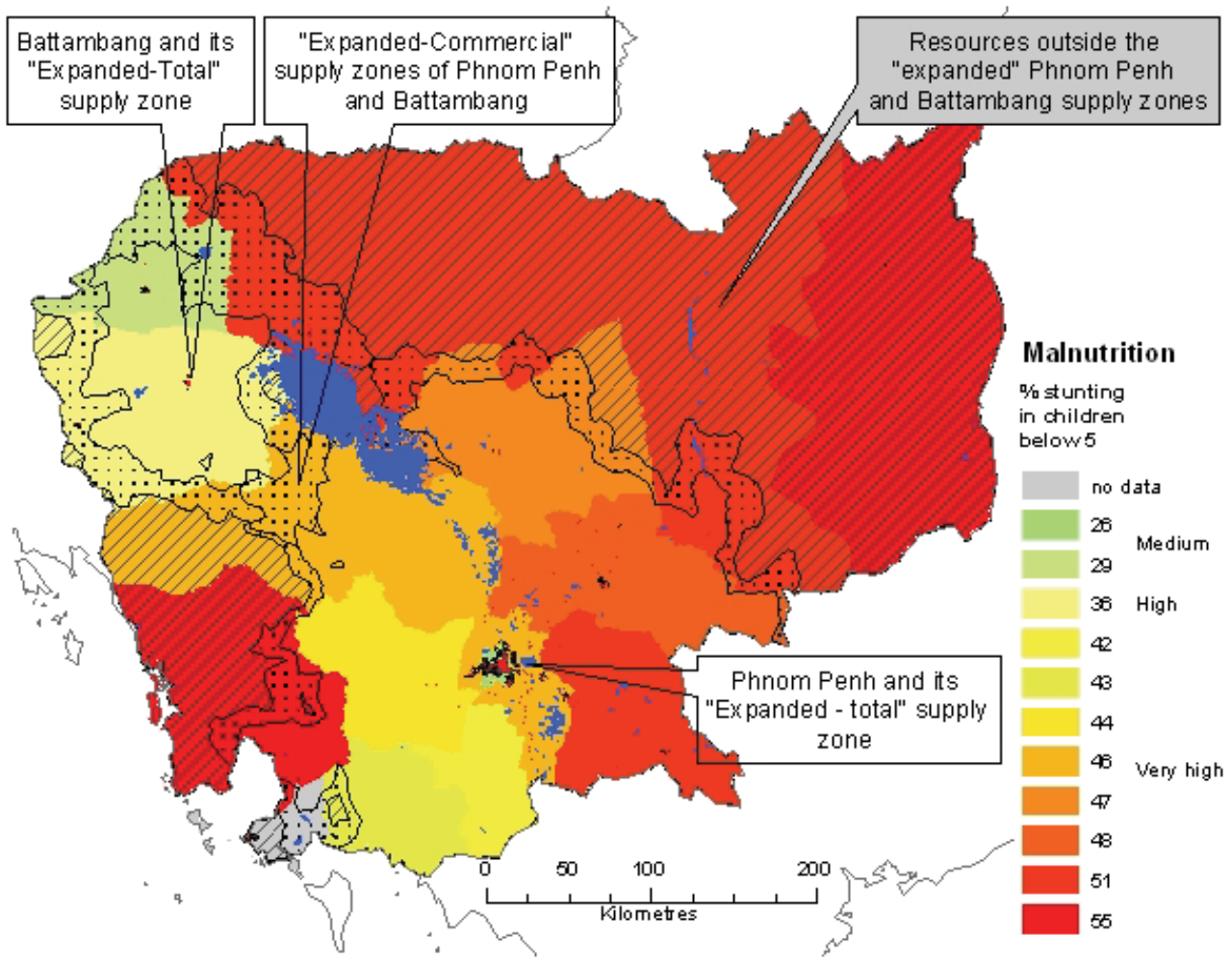


TABLE 9
Population and nutritional statistics within the Phnom Penh and Battambang woodsheds

		Battambang supply zones				Phnom Penh supply zones				Cambodia country total
		Restricted		Expanded		Restricted		Expanded		
		Total	Comm.	Total	Comm.	Total	Comm.	Total	Comm.	
Area	km^2	4 200	10 900	10 900	27 500	13 900	39 900	60 100	70 400	180 836
Population	('000)									
Urban		91	116	116	232	1 856	1975	1 999	1 999	2 308
Rural settlements		262	334	334	440	1 223	2 445	2 655	2 672	3 143
Sparse rural		431	861	861	1 843	1 613	4 128	5 132	5 461	7 659
Total		784	1 311	1 311	2 515	4 693	8 548	9 786	10 131	13 109
Malnutrition										
Stunting*	%	36	35	35	38	43	45	45	45	46

* Percentage of children under five showing stunt growth.
WHO categories: <20% = low; 20–29% = medium; 30–39% = high; ≥40% = very high.

According to the thresholds indicated in the WHO classification of malnutrition, stunting conditions are ranked as very high (incidence **≥**40 percent), high (30–39 percent), medium (20–29 percent) and low (<20 percent). With reference to these thresholds the situation in Cambodia appears to be extremely serious, with a national average of 46 percent. But the situation is not homogeneous, as shown in Figure 28; the conditions within the Phnom Penh and Battambang woodsheds are significantly different, with a stunting incidence of "only" 35–38 percent in the latter and 43–45 percent in the former. This factor plays an important role in the selection of priority areas of intervention, especially when these imply the creation of rural markets and the adoption of poverty alleviation measures.

Vientiane and Luang Prabang woodsheds

The situation in the woodshed areas of Vientiane and Luang Prabang in the Lao People's Democratic Republic is quite different (Figure 30). As shown in Tables 10 and 11, the urban populations within the supply zones of these two cities are much smaller than in Cambodia. Although the precision of these figures is limited, because of the process of spatialization and the fairly subjective definition of rural/urban conditions in reference sources (FAO, 2005b), the order of magnitude they provide is consistent.

Given the relatively low population density also in peri-urban and rural areas, the factor that most influences the size of the zones is the type of supply, i.e. total versus commercial, rather than the inclusion or exclusion of consumption outside the cities (restricted-expanded). In the case of Luang Prabang, for instance, the suburban and rural consumption is so low that the restricted-commercial and expanded-commercial supply zones are roughly the same (see Section 5.2.2).

FIGURE 30
Vientiane and Luang Prabang woodshed zones

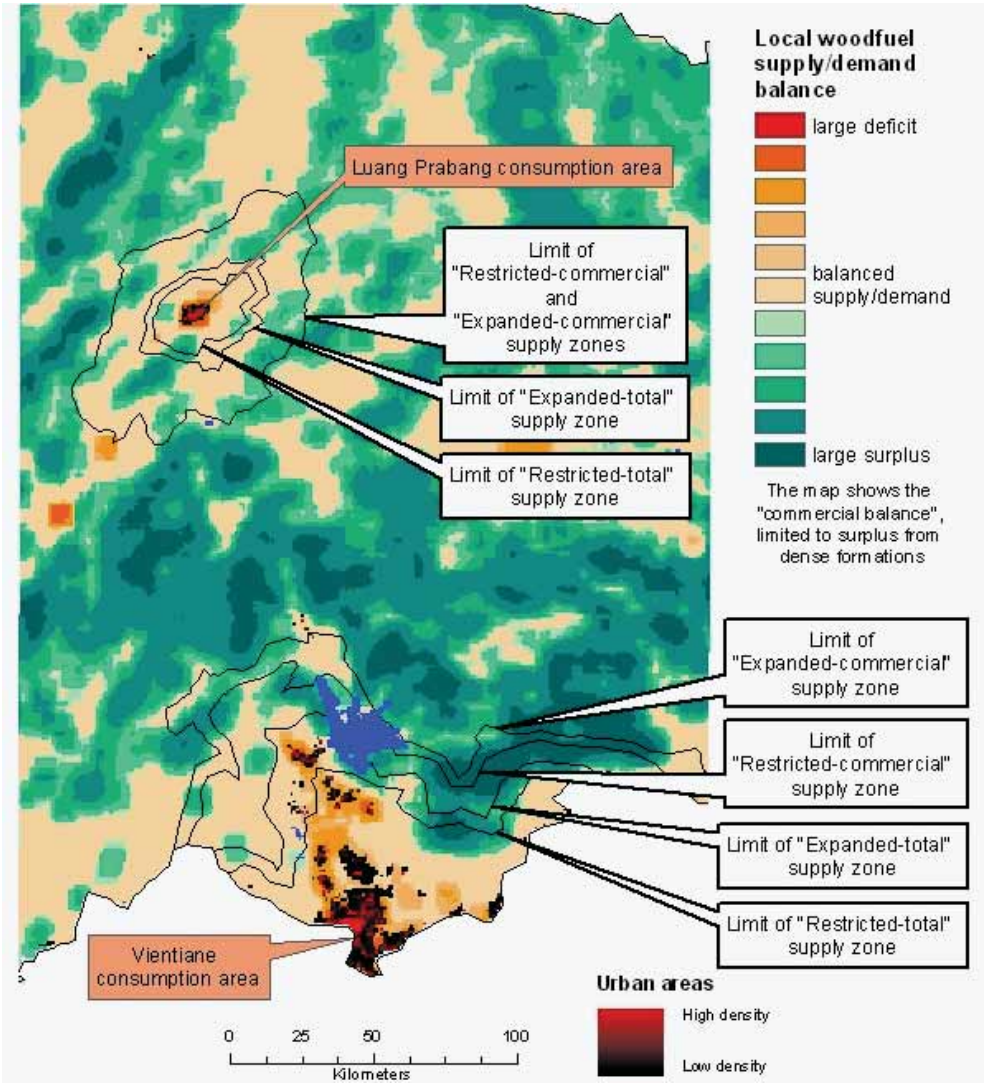


TABLE 10
Main statistics for Vientiane woodshed zones

		Vientiane supply zones			
		Restricted		Expanded	
		Total	Commercial	Total	Commercial
Area of supply zone	km^2	3 600	7 700	5 100	9 500
Annual consumption (2000)	$t*yr^{-1}$	259 000	259 000	473 100	500 200
Potential annual supply or surplus	$t*yr^{-1}$	321 100	268 300	545 500	551 000
Population ('000 inhabitants)					
Urban		570	620	620	630
Rural settlements		50	70	70	80
Sparse rural		150	210	190	230
Total population		770	900	880	940

TABLE 11
Main statistics for Luang Prabang woodshed zones

		Luang Prabang supply zones			
		Restricted		Expanded	
		Total	Commercial	Total	Commercial
Area of supply zone	km^2	800	4 400	1 300	4 400
Annual consumption (2000)	$t*yr^{-1}$	53 600	53 600	73 500	101 600
Potential annual supply or surplus	$t*yr^{-1}$	65 900	73 300	112 400	107 700
Population ('000 inhabitants)					
Urban		70	70	70	70
Rural settlements		10	20	20	20
Sparse rural		20	80	40	80
Total population		100	170	130	170

5.3.2 Selected East African urban woodsheds

The East African WISDOM geodatabase presents several differences with regard to that of Southeast Asia, which influence the delineation of urban woodsheds. These differences include i) a higher resolution of woodfuel supply maps that were based on Africover vector maps (Africover Web site) with minimum mapping units of 200–300 m (below 100 m width for linear features), compared with the 0.9 km pixel size (30 arc-sec) of the Southeast Asian maps; and ii) a lower resolution of the woodfuel supply/demand balance maps, for which a cell size of approximately 9 x 9 km (5 arc-min) was used, compared with the Southeast Asian pixel size, which was 0.9 km. The result is that the mapping of supply sources is more detailed, while the spatial definition of the supply zones, based on the 5 arc-min data set, is coarser.

Dar-es-Salaam and Arusha-Moshi, United Republic of Tanzania

Given the comparatively high concentration of wooded landscapes (woodlands and bushlands) in the proximity of the city, the urban woodshed of Dar-es-Salaam is relatively small, as shown in Figure 31 and summarized in Table 12, with all supply zones within some 150 km from the city, including the expanded-commercial zone.

Findings from the land cover change study conducted by the CHAPOSA project (CHAPOSA, 2002) to assess the impact of charcoal production around Dar-es-Salaam show considerable degradation of woodlands and shrublands over an area that is roughly as big as the restricted-total supply zone in Figure 31. This may indicate that the sustainable supply zone should be larger, in order to allow longer rotations and enough time for exploited woodland to recover. It may also indicate that the sustainable productivity assumed in the WISDOM study is optimistic and should be lower. In any case, this confirms the need to proceed with field-level investigations and verification after the nationwide WISDOM analysis and the first delineation of urban woodshed zones.

In Dar-es-Salaam, the sparse rural population located within the area of influence and potentially involved in woodfuel production varies between 0.6 million for the restricted-total supply zone and 0.9 million for the expanded-commercial one.

A totally different situation results from an analysis of the urban woodshed of Arusha-Moshi in the Kilimanjaro region (Figure 32 and Table 13). The combination of i) the high population density (and woodfuel demand) of the northeast and central regions of the country; and ii) the scarce woody biomass resources of the area generates a much wider expanded-total supply zone and an expanded-commercial zone that covers half the country.

FIGURE 31
Dar-es-Salaam woodshed zones

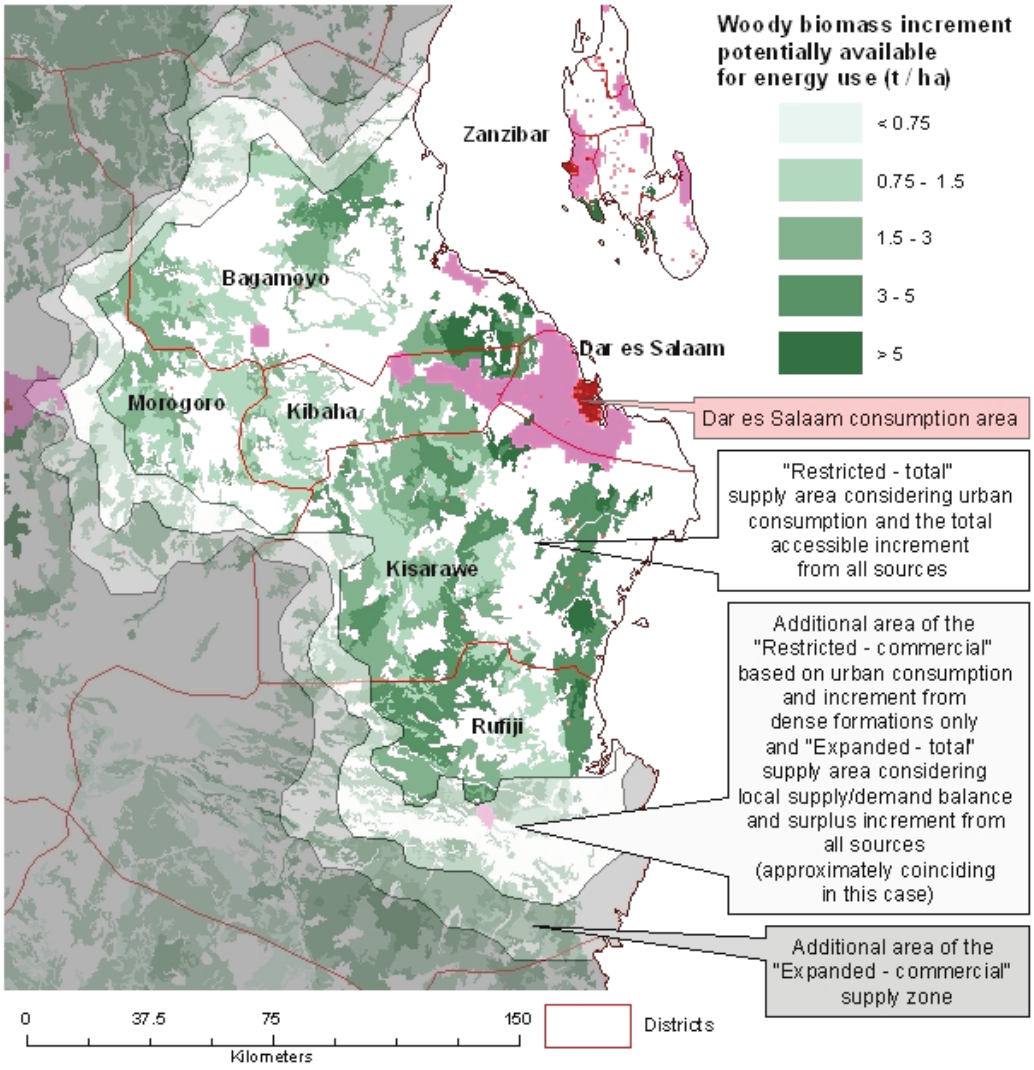


TABLE 12
Main statistics for Dar-es-Salaam woodshed zones

		Dar-es-Salaam supply zones			
		Restricted		Expanded	
		Total	Commercial	Total	Commercial
Area of supply zone	km^2	19 000	24 000	24 000	30 000
Annual consumption (2000)	$t*yr^{-1}$	2 200 000	2 200 000	2 500 000	2 600 000
Potential annual supply or surplus	$t*yr^{-1}$	2 800 000	2 500 000	2 800 000	2 900 000
Population ('000 inhabitants)					
Urban		2 090	2 090	2 090	2 180
Rural settlements		0	0	0	0
Sparse rural		580	710	710	860
Total population		2 670	2 800	2 800	3 040

FIGURE 32
Arusha-Moshi woodshed zones

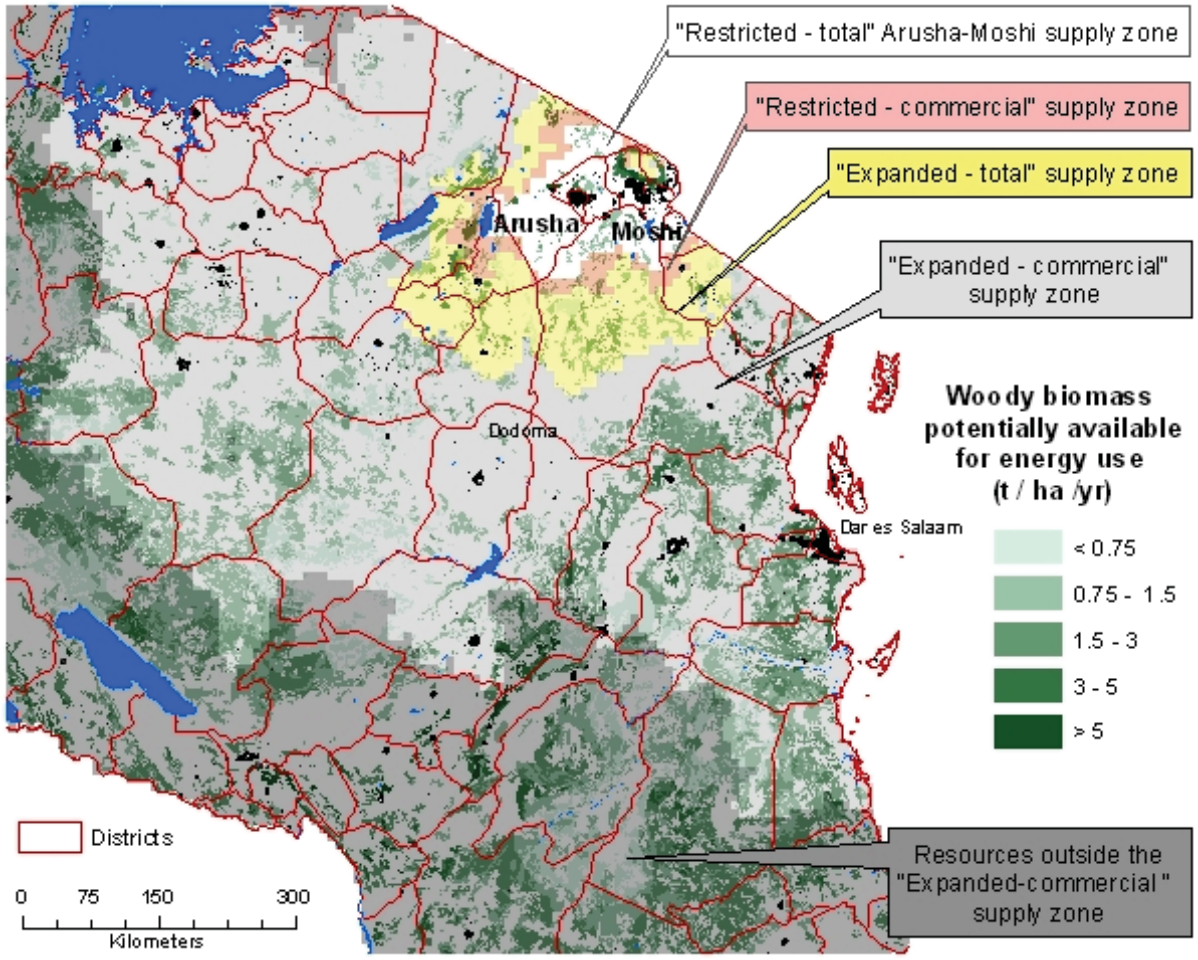


TABLE 13
Main statistics for Arusha-Moshi woodshed zones

		Arusha-Moshi supply zones			
		Restricted		Expanded	
		Total	Commercial	Total	Commercial
Area of supply zone	km^2	22 000	32 000	73 000	459 000
Annual consumption (2000)	$t*yr^{-1}$	1 000 000	1 000 000	3 300 000	16 700 000
Potential annual supply or surplus	$t*yr^{-1}$	1 100 000	1 000 000	3 400 000	16 900 000
Population ('000 inhabitants)					
Urban		1 190	1 240	1 400	5 010
Rural settlements		0	0	0	0
Sparse rural		920	1 220	2 240	14 450
Total population		2 110	2 460	3 640	19 460

Even Dar-es-Salaam is included in the expanded-commercial supply zone of Arusha-Moshi, as an effect of the progressive inclusion of additional buffers, for which both potential supply and local consumption are

added, until cumulative consumption and supply balance out. The Arusha-Moshi case study shows the importance of backing the analysis of the urban woodshed of a particular city with a wall-to-wall WISDOM analysis. In fact, the combination of factors outside the city strongly influences the size and shape of the urban woodshed, even at considerable distance. It also stresses the benefits of undertaking urban woodshed analysis for several cities in a country, in order to achieve a comprehensive vision of urban/rural interaction and to fine-tune the urban woodshed of interest.

Kampala, Uganda

At the time of writing, there is a report in the press that "Wood scarcity hits Kabale", a district in southeast Uganda, detailing that households have resorted to cooking with coach grass and crop residues because of the scarcity of fuelwood. Until recently, the report says, there were plenty of trees on the hilltops but with a growing population, most trees have been felled to create land for cultivation. Unsurprisingly, the district was listed among the subnational units of Uganda with the highest woodfuel deficit in the East African WISDOM study (FAO, 2006b).

The scarcity of woody biomass for household energy in Uganda is a well-recognized problem and this is reflected also in the urban woodshed analysis of Kampala. The supply zones, shown in Figure 33 and summarized in Table 14, are very large considering that Kampala has a population of "only" 1.2 million.

What emerges clearly from the analysis is that the sources of woody biomass are prevalently fragmented, degraded and of low density, which explains the large difference between the restricted-total and the restricted-commercial supply zones. The remaining dense formations, which are more suitable for commercial woodfuel production, are scarce and distant, extending the restricted-commercial supply zone to some 200 km from the city.

The situation is more serious when accounting for local consumption outside the city. The expanded-total zone covers some 91 000 km^2 with distances over 200 km from the city, while from the expanded-commercial perspective there is a debit balance even if the supply zone includes the whole country.

It should be borne in mind that supply zone definitions are theoretical, always assuming sustainable exploitation regimes. In this respect, the situation in Uganda indicates a strong risk of overexploitation and protracted degradation of natural resources.

Khartoum, the Sudan

The larger city of Khartoum, with the nearby urban areas of Rufaa and Wad Medani, has almost 5 million inhabitants and there is consequently a tremendous demand for charcoal and fuelwood for household energy, according to recent consumption studies.

Given the high demographic concentration in the central Sudanese regions and the relative scarcity and low productivity of wood resources, supply zones are extremely large, as shown in Figure 34 and summarized in Table 15. Woodfuel supply zones reach a considerable distance: up to 500 km for the restricted-total zone, and a need to reach the biomass-rich southern provinces over 1 000 km away for the expanded-commercial one.[9]

The production of fuelwood and charcoal represents a source of income for large numbers of sparse rural communities living in these areas.

[9] Note that the shape of the supply zones in Figure 33 is based exclusively on resource distribution and physical/legal accessibility parameters, not accounting for the certain (but undefined) impact exerted by the conflict that opposes the southern part of the country, rich in forests and woodlands, to the central part where most of the woodfuel demand is concentrated.

FIGURE 33
Kampala woodshed zones

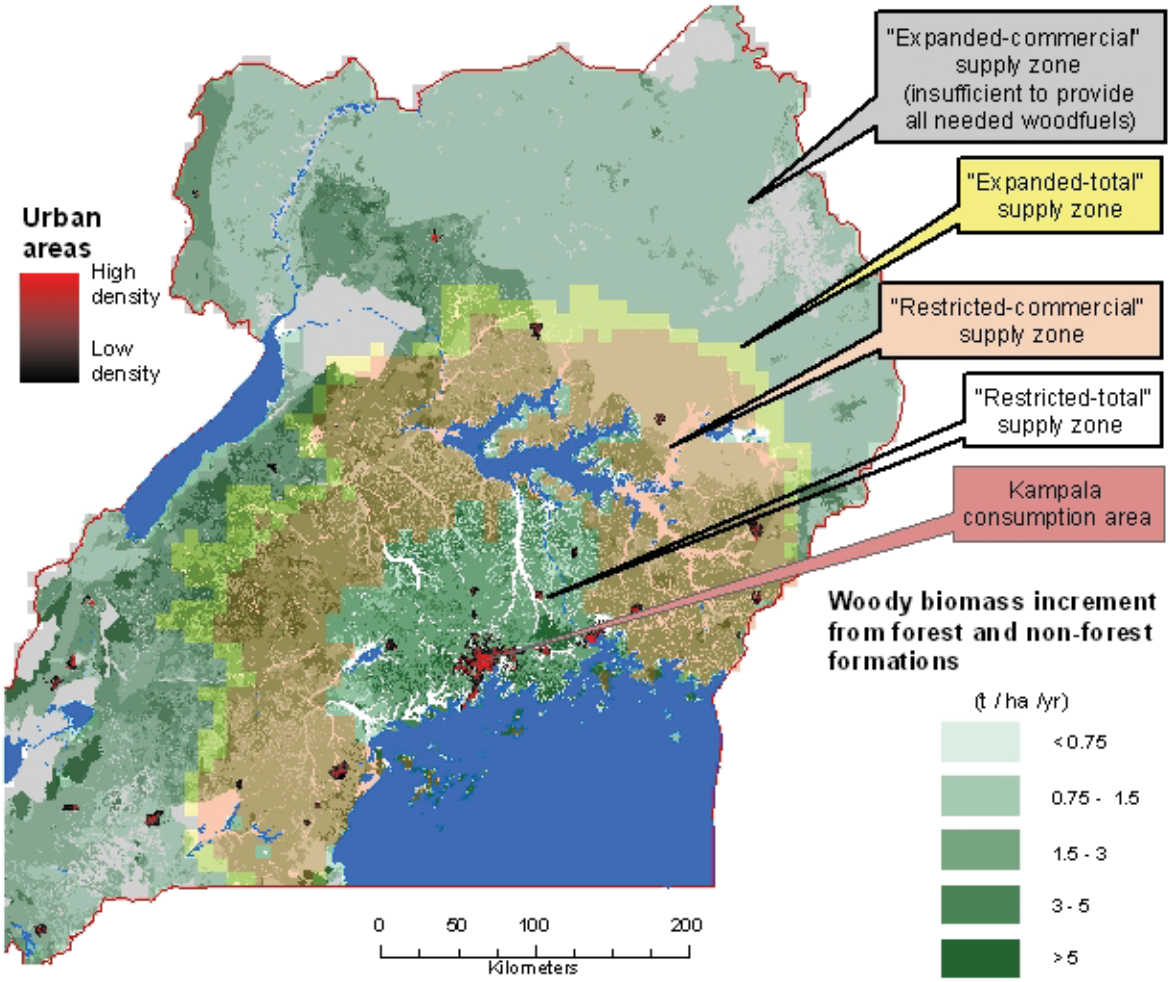


TABLE 14
Main statistics for Kampala woodshed zones

		Kampala supply zones			
		Restricted		Expanded	
		Total	Commercial	Total	Commercial *
Area of supply zone	km^2	19 000	78 000	91 000	202 000
Annual consumption (2000)	$t*yr^{-1}$	2 600 000	2 600 000	11 500 000	**17 600 000**
Potential annual supply or surplus	$t*yr^{-1}$	3 100 000	2 600 000	11 900 000	**13 700 000**
					-3 900 000
Population ('000 inhabitants)					
Urban		2 340	2 820	2 840	3 270
Rural settlements		520	2 100	2 180	3 080
Sparse rural		2 120	8 290	9 170	16 540
Total population		4 980	13 210	14 190	22 890

*The expanded-commercial supply zone appears insufficient to provide the needed woodfuel even if extended over the entire country. The potential supply from the commercial surplus (13.7 million tonnes) is less than the total estimated consumption (17.6 million tonnes).

FIGURE 34
Khartoum woodshed zones

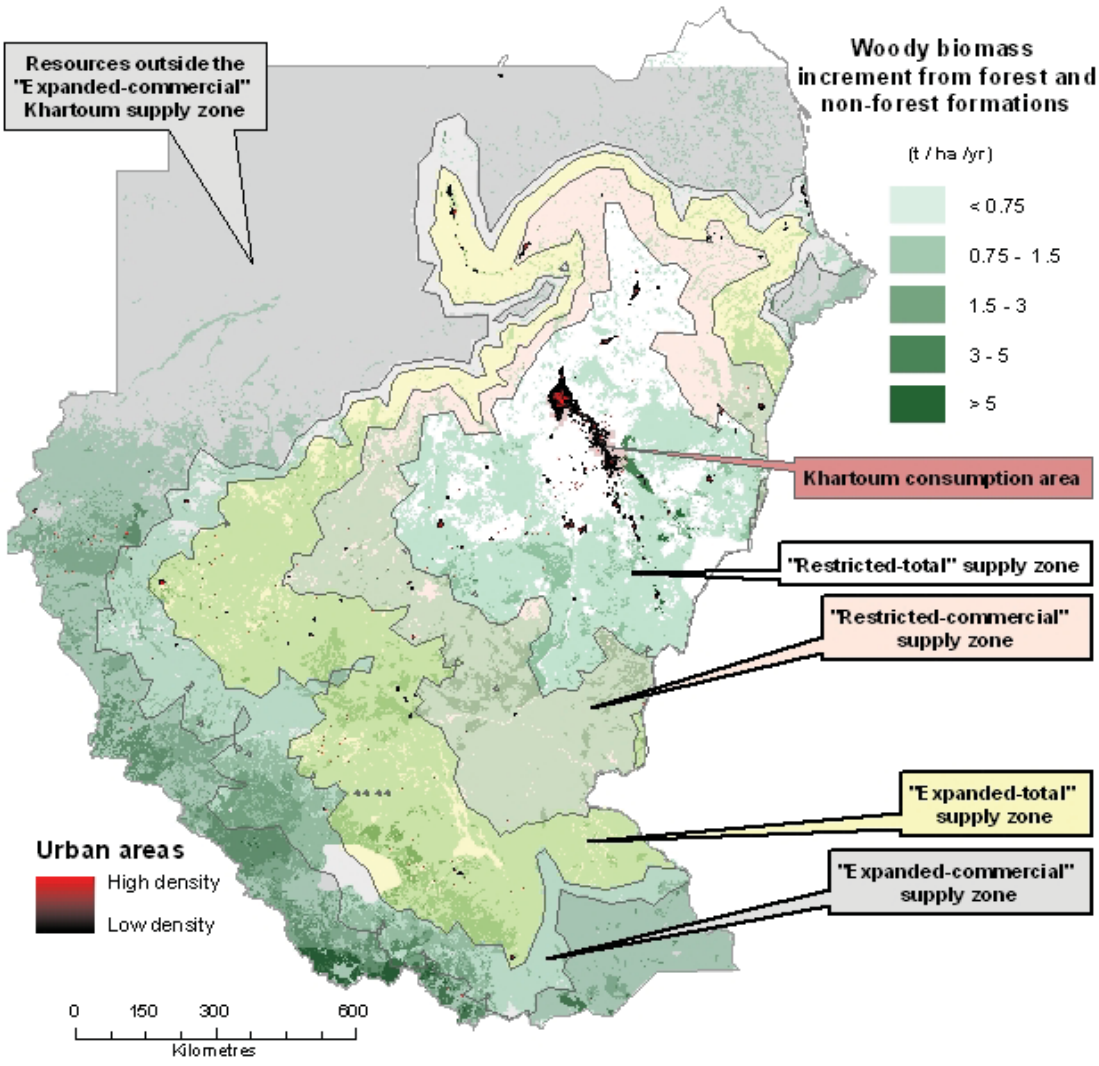


TABLE 15
Main statistics for Khartoum woodshed zones

		Khartoum supply zones			
		Restricted		Expanded	
		Total	Commercial	Total	Commercial
Area of supply zone	km^2	399 000	760 000	1 260 000	1 550 000
Annual consumption (2000)	$t*yr^{-1}$	3 900 000	3 900 000	1 636 900 000	1 814 300 000
Potential annual supply or surplus	$t*yr^{-1}$	4 000 000	3 900 000	1 637 400 000	1 815 200 000
Population ('000 inhabitants)					
Urban		8 060	9 010	10 280	11 000
Rural settlements		0	0	0	0
Sparse rural		7 130	10 340	14 720	16 710
Total population		15 190	19 350	25 000	27 710