Annex 8

Call for public inputs in relation to standardized approaches for facilitating the baseline emission calculations under AMS-I.E "Switch from non-renewable biomass for thermal applications" and AMS- II.G "Energy efficiency measures in thermal applications of non-renewable biomass"- SSC CDM methodologies for displacement of non-renewable biomass

1. As per the task of developing standardized baselines contained in the 2011 work plan of the SSC WG, the SSC WG initiated at its 31st meeting its work on standardized approaches for simplifying baseline emission calculations in AMS-I.E "Switch from non-renewable biomass for thermal applications" and AMS-II.G "Energy efficiency measures in thermal applications of non-renewable biomass", focusing on:

a) approaches for deriving regional/country specific values for the fraction of non-renewable biomass;

b) default parameters for baseline fuelwood consumption per capita or per household.

2. With reference to the estimation of the fraction of non-renewable biomass, based on expert and stakeholder inputs, the SSC WG 33 considered the following methodological approaches for deriving regional/country specific default values for the fraction of non-renewable biomass:

(i) Approach based on Woodfuel Integrated Supply/Demand Overview Mapping methodology[1] (WISDOM): This is a systematic approach for estimating fNRB defaults at national and sub-national levels based on integrating the concept of the Sustainable Increment Approximation Fraction (SIAF) into the Woodfuel Integrated Supply/Demand Overview Mapping methodology. A detailed technical description and graphical presentation of this approach is provided in the technical report attached to this document (attachment A). The application of the method derives the fractions of non-renewable biomass at sub-national levels by incorporating spatial variations of the biomass and population data for the geographical areas from which the woody biomass is extracted, their sustainable production capacity and their existing management systems;

(ii) Approach based on Mean Annual Increment (MAI): This approach estimates the fraction of non-renewable biomass based on the quantification of the difference between the fuel wood consumption of households and the adjusted mean annual increment of biomass growth. A detailed technical description of this approach is provided in the technical report attached to this document (attachment B). This approach draws on available national and regional (within a country) forestry data while providing opportunities for input and adjustments from experts such as DNAs and local forestry professionals. The approach can determine aggregate country specific values for the fraction of non-renewable biomass using a set of standard calculations included in Attachment B.

[1] The Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) method was developed by FAO in collaboration with the Center for Ecosystems Research of the National University of Mexico and implemented in many countries worldwide. For details on WISDOM method and case studies, see www.wisdomprojects.net.

3. The SSC WG agreed to request the Board to launch a call for public inputs on the proposed approaches for quantifying the fraction of non-renewable biomass in order to select the most appropriate approach for deriving reliable and conservative estimates for the fraction of non-renewable biomass. To this objective, the SSC WG is looking for feedback on:

- Practicality and appropriateness of the defined approaches for estimating the fraction of non-renewable biomass;
- The frequency with which the values for fraction of non-renewable biomass should be updated;
- The level of aggregation that can reliably represent the non-renewability of displaced biomass;
- Other approaches for determining fNRB that should be assessed (e.g. net-to-gross adjustment with simple discount for baseline emission). If any, please provide further justification on the proposed approach(es).

4. With reference to default values for fuel wood consumption per capita and per household, the SSC WG prepared a list of regional-specific default values, provided in the table below, that may be included as an option for quantifying the amount of biomass displaced:

Table 1: Regional default values for woodfuel consumption per person and per household[2]

Region	Tons/HH-Year	Tons/Person-Year	m3/HH-Year	m3/Person-Year
Africa	3.52	0.66	5.46	1.02
West Sahelian Africa (WSA	2.31	0.44	3.59	0.68
East Sahelian Africa (ESA)	3.40	0.64	5.28	1.00
West Moist Africa (WMA)	3.64	0.69	5.65	1.07
Central Africa (CA)	3.50	0.66	5.43	1.02
Tropical Southern Africa (TSA)	4.70	0.89	7.29	1.38
Insular East Africa (IEA)	2.86	0.54	4.44	0.84
North Africa (NA)	0.60	0.11	0.94	0.17
Non Tropical Southern Africa	3.58	0.67	5.54	1.05
East Africa (rural)	3.32	0.63	5.14	0.97
Arid and sub-arid Africa	1.71	0.32	2.65	0.50
Savanna area	4.27	0.81	6.63	1.25
High Forest Areas	4.96	0.94	7.69	1.45
Mountanous Areas	5.64	1.06	8.75	1.65
Asia	3.29	0.63	5.10	0.97
High forest areas	3.62	0.71	5.61	1.10
Mountainous	5.10	1.00	7.91	1.55

[2] Sources used for deriving the average values are UNEP Wood Energy in Africa Report, 1994 Wood Fuel Survey, FAO 1983; FAO Asia Regional Study, etc.

areas				
Latin America	4.32	0.96	6.70	1.49
Andean plateau	3.95	0.82	6.12	1.28
Arid areas	2.32	0.48	3.60	0.75
Semi-arid areas	2.94	0.61	4.56	0.95

5. The group agreed to request the Board to launch a call for public inputs on the appropriateness of the inclusion of regional default values for fuel wood consumption. To this objective, the SSC WG is looking for feedback on:

- Whether providing default woodfuel consumption aggregated at a regional level is considered practical from the project implementation point of view or if another level of aggregation would be more appropriate?
- With what a frequency should these default values be updated?

Attachment A - Approach based on WISDOM

Technical Report

Methodology for the systematic and coherent estimation of default fNRB at national and sub-national level (based on the WISDOM method)

Overview: Scope of the Report

This report aims at providing a reliable, consistent, cost-effective and globally applicable method to derive default values for the fraction of non-renewable biomass (fNRB) at national and first-order sub-national levels (state or provinces) using the WISDOM model.

Providing reliable and consistent fNRB estimates across countries and regions has been a major problem for SS CDM Projects since its inception. On the one hand, fNRB values are not readily available in the literature. Also current approved methodologies do not include clear provisions for a standard calculation of fNRB. Finally, performing a sound analysis to determine fNRB values at the project level is not trivial, requires high-level technical skills, and adds a significant transaction cost to the project.

To solve this problem, we should note first, that the fNRB is location-specific, i.e., there are very large variations within countries and regions. National summary values based on statistical data cannot capture this fundamental aspect and may give misleading results. It is where, how and how much biomass is extracted that makes it renewable or not renewable. Also, the accurate estimation of the fNRB for a specific location requires precise information on the geographical areas from which the consumed biomass is extracted, their sustainable production capacity and on the existing management systems.

Providing spatial-explicit estimates of fNRB has the added value of helping focusing and priorizing project implementation to those areas within countries where the values are highest, and therefore maximizing both the global (largest mitigation per device) and the local (largest income from carbon sales) benefits.

The WISDOM model is suited to provide this type of spatial-explicit estimates of fNRB as it has been used and validated in more than 20 country, regional, and local case studies throughout the world.

In what follows, we provide a detailed and transparent description of the method proposed, and illustrate it for the case of 11 developing countries. The data to develop the examples comes from existing WISDOM studies and therefore is not completely standardized in terms of reference year or sources. It is only meant to provide a first illustration of what could be achieved in terms of fNRB estimates.

We also explain how this method could be applied globally, using existing and publicly available georeferenced databases on land cover and other relevant parameters for the estimation of biomass supply, population, woodfuel consumption and other variables.

It should be noted that project developers, will only need to consult a set of tables with the final fNRB values (as it is done routinely with default emission factors) and by no means will need to do any of the calculations illustrated here. These default fNRB values could be part of a TIER 1 approach, leaving projects the option to provide local-estimates if they desire to do so.

1. Conceptual aspects: The need for spatial approaches

The fraction of non-renewable biomass is location-specific. National summary values based on statistical data cannot capture this fundamental aspect and may give misleading results. It is where, how and how much biomass is extracted that makes it renewable or not renewable, and national statistics cannot tell that, even if they are consistent and reliable (which is rare).

The accurate estimation of the fNRB for a specific location requires precise information on the areas from which the consumed biomass is extracted, their sustainable production capacity and on the existing management systems. Such knowledge is definitely unavailable on a systematic basis at aggregate level (i.e., countries) and it's quite rare even at the local level.

However, the use of the Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) method may support the estimation of the expected fNRB values for geographical regions – countries, states, provinces-, thanks to the systematic geo-referenced estimation of the consumption and of the sustainable productivity of woody biomass and its accessibility (physical, legal and economic).

The Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) method was developed by FAO in collaboration with the Center for Ecosystems Research of the National University of Mexico and implemented in many countries worldwide. Fundamental features of WISDOM are spatial-explicit analysis of (i) the demand for woody biomass for energy and other competing uses in all sectors of use, (ii) the supply potential from all direct and indirect sources (forests, woodlands, farmlands, industrial residues), (iii) the supply/demand balance in a local and informal fuelwood-gathering context and in a wider commercial context, and (iv) the outline of the sustainable supply zone of selected consumption sites (woodshed analysis).[3]

WISDOM distinguishes two geographic contexts for supply/demand balance analysis, which are critical for an accurate fNRB estimation: "local" and "commercial" wood energy.

Local and Commercial wood energy contexts

Concerning the spatial relation between wood energy supply and demand, two distinct contexts may be observed:

- **Local supply/demand context**, which is typical of rural areas. The supply is based on fuelwood collection and/or charcoal production directly by the end users or by small temporary producers. The system is largely informal and the geographic horizon is limited to few kilometers from the consumption sites.
- **Commercial supply/demand context**, which includes urban demand and more or less distant supply zones. Fuelwood and charcoal are here market commodities that feed a chain of operators, such as producers, transporters, retailers and the supply zone can be at considerable distance from the consumption sites.

WISDOM can contribute to the analysis of both systems, which require different approaches. The Local context can be mapped with relative ease, while the Commercial one –linked to urban areas- is more complex to model. In fact, the estimation of the fNRB related to urban consumption requires knowledge about the location and extent of the actual woodfuels supply sources. Without

[3] For details on WISDOM method and case studies, see www.wisdomprojects.net.

such information, the estimation of the *expected* fNRB can only be done through spatial modeling and the uncertainty remains high.

In the context of the present study, in order to provide fNRB estimates without involving complex GIS processing, we propose the analysis to be done by 1st level sub-national units (or 2nd level for large countries).

For analytical purposes, the following situations are distinguished:

- rural areas (with an horizon of 5-6 km around populated places),
- urban areas (usually defined by census data), and
- areas uninhabited or sparsely populated (areas with less than 10 inhabitants per km^2).

2. Estimation of fNRB based on existing WISDOM case studies – analytical steps

As noted, producing a single estimate of fNRB at aggregate geographical levels (such as a country) may fail to represent the true condition for an hypothetical project area as the impacts of fuelwood harvesting depend not on the overall balance between the fuelwood supply and consumption, but on the way consumption translates into harvesting practices (i.e., the type of management systems that are used to extract fuelwood) and the spatial patterns of these harvesting practices. For example if fuelwood extraction is concentrated in few forest spots where intensive clear-cutting w/o re-planting is conducted, the impact will be very different to a system where harvesting is more evenly distributed in the forest area.

To get to the expected fNRB at sub national level, a step-wise process of analysis is proposed.

Step 1: Estimation of the "**potential Renewable Biomass fraction**" (**pRBf**), i.e., the highest possible degree of renewability of a given biomass harvesting within a particular territory.

Step 2: Estimation of the "**<u>minimum</u> <u>fraction of Non-Renewable Biomass</u>**" (**mfNRB**). Based on the pRBF defined through the previous step, the mfNRB indicates the best possible situation of non-renewable use, given the estimated level of harvesting and the supply potential, and assuming the rational management of biomass resources.

Step 3: Estimation of the **Sustainable Increment Exploitation Fraction** (**SIEF**). This parameter indicates how rationally the harvesting within a given area is carried out or, more specifically, what fraction of the sustainable increment is actually exploited.

Step 4: Estimation of the "**expected Renewable Biomass fraction**" (**eRBf**), i.e., the likely degree of renewability of a given biomass harvesting within a particular territory assuming "current" management practices. This parameter is estimated by applying the SIEF to the pRBf.

Step 5: Estimation of the "**<u>expected</u> <u>fraction of Non-Renewable Biomass</u>**" (**efNRB**). Based on the eRBF defined through the previous step, the efNRB indicates what the likely situation may be, given the estimated level of harvesting and the supply potential, and assuming current management practices.

Step 1: Estimation of the "potential Renewable Biomass fraction" (pRBf),

The estimation of the "*potential* Renewable Biomass fraction" (pRBf) is the most demanding analytical step, since it implies the estimation, and mapping, of the sustainable biomass supply potential and consumption. In fact, this step includes the application of the entire WISDOM model.

Based on the geo-referenced WISDOM layers on supply and demand and further processing described below, the pRBf is estimated as the highest possible degree of renewability of a given biomass harvesting within a particular territory. To do so we assume that the biomass resources are rationally exploited (i.e. the sustainable increment is the first to be exploited and, in case that the demand is higher than the sustainable supply, the sustainable increment of the area is exploited entirely).

The <u>pRBf</u> within a given territory can be formulated as follows:

(1) ***potential* Renewable Biomass fraction (pRBf)** (of a given administrative unit)**:**

(<sustainable supply potential> - <harvesting>) / <harvesting>

The <sustainable supply potential> can be estimated and mapped using available information[4] while <harvesting> is rarely known. However, it can be assumed that within a country <harvesting> is equal to <consumption> [- import + export], which is a key parameter of the WISDOM model[5] that can also be estimated and mapped on the basis of available information.[6]

Concerning the spatial relation between <harvesting> and <consumption>, the following two main aspects must be considered:

- In a local supply/demand context, typical of rural areas, there is a tight spatial relation between harvesting sites and consumption sites. It is reasonable to assume that within a sub-national unit the <harvesting> for rural consumption is equal to rural <consumption>.
- In a commercial supply/demand context typical of urban areas, the local spatial relation between harvesting sites and consumption sites is lost. As mentioned above, the supply zone of urban woodfuel markets may include production areas quite far from the cities. In such cases, assuming that the biomass supply of urban centers comes only from the unit where the cities are located would produce misleading results. In order to overcome this problem in absence of information on the actual supply areas, the harvesting relative to urban consumption for the major urban centers can be "distributed" over the biomass sources of the neighboring administrative units on the basis of urban woodshed analyses[7] (see Figure 1) and proportionally to their supply potential.

The woodshed analysis tells what ***should be*** the harvesting area in order to guarantee the sustainable supply of the needed woody biomass, assuming rational resources management. The woodshed analysis doesn't tell what the *actual* harvesting area is, which would allow an accurate estimation of the fNRB, but it provides a revealing vision of the territory under urban influence.

As an example, Figure 1 provides a graphic of the analytical process applied in case of Cambodia.

The top map shows the woodshed of the cities of Cambodia above 50,000 inhabitants in 2000. The buffers around the selected cities are determined by physical accessibility factors (roads, slope, land cover, etc.) and by the woodfuel demand of each city considered. Cities with higher demand (like Phnom Penh) "produce" wider buffers while the cities with lower demand "produce" narrower buffers, well representing the territory under urban influence/pressure. The red outline in the top map shows the sustainable supply zone: within this area the total consumption -urban and rural- matches the sustainable supply potential.

The second map shows the administrative units that were considered under most immediate urban influence, on which the urban consumption was then distributed and projected,[8] and thus "converted" into harvesting levels induced by urban demand. In this way the estimated harvesting includes and combines both rural and urban biomass demand components.

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[4] See list of data sources suitable for global analysis of woody biomass supply potential in the next section.
[5] In WISDOM, all woody biomass use is considered, including woodfuels as well as industrial wood products and construction material. Industrial roundwood production is usually deducted from the available wood energy supply potential while construction material used by rural households is added to the woodfuel consumption.
[6] See list of data sources suitable for global analysis of woody biomass consumption in the next section.
[7] The woodshed analysis serves to outline the sustainable supply zone of a city based on (i) the city's biomass demand and (ii) the distribution and accessibility of the biomass surplus suitable for commercial supply on the territory around the city. See Drigo and Salbitano, 2008, for a description of woodshed analysis.
[8] In the algorithm applied on the case studies here presented the distribution of urban consumption on neighboring administrative units was done proportionally to the accessible supply potential of each unit. For future analyses we are envisaging a spatial algorithm based on woodshed analysis modulating the estimated harvesting intensity based on accessibility (distance, slope, etc.).

The subsequent step of analysis implied the calculation of the potential Renewable Biomass fraction (pRBf) for each sub national unit according to formula (1).

It should be noted that the pRBf value ranges between -1 and $+\infty$.

- Positive values indicate that the harvested biomass is less than the supply potential and the biomass extracted is potentially "renewable". The value shows the margin of surplus as the ratio between the supply potential and current harvesting level within the area under consideration.
- Negative values indicate that the harvesting is more than the sustainable supply potential and show the fraction of the consumption that cannot be met by the sustainable supply capacity of the area under consideration.

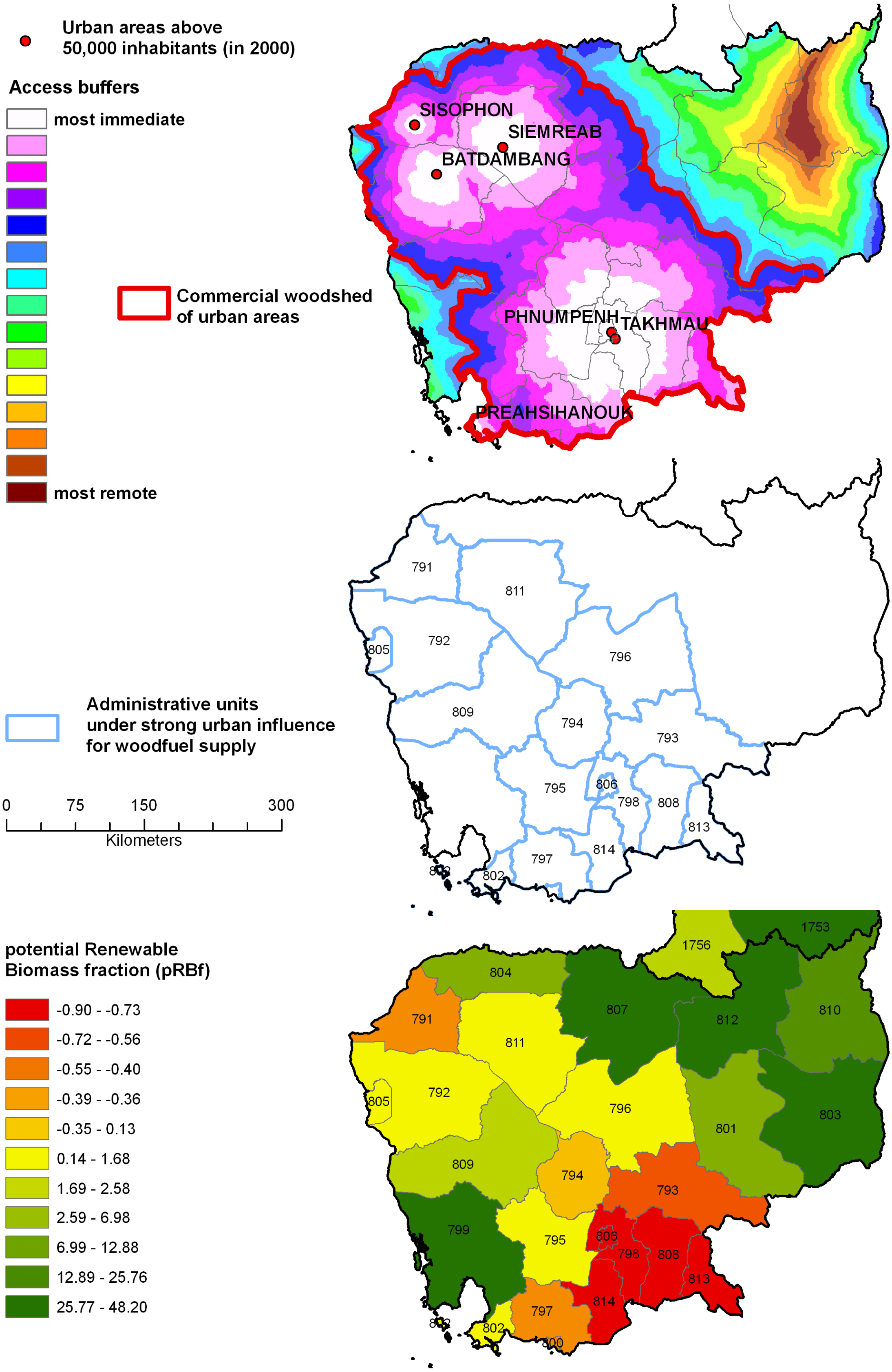
The third map of Figure 1 shows the pRBf values for Cambodia sub national units (which are prelude to the estimation of the minimum fraction of Non Renewable Biomass –mfNRB- discussed below).

One main conclusion from Figure 1 is that there is a wide variability within the country concerning the harvesting pressure, pRBf and, eventually, the fNRB values. Therefore, a single national average, no matter how accurate this may be, would inevitably fail to represent such variability.[9]

It's worth emphasizing that pRBf represents the best possible situation given the resources available within the study area, and not the actual situation, which depends on how rationally such resources are exploited.

[9] In fact, the national fNRB average of 48.4% (see the Cambodia total in Annex 1) would be either too high or too low, depending on the location and size of an hypothetical project area.

Figure 1: Example of woodshed analysis, distribution of urban consumption on neighboring units and estimation of potential Renewable Biomass fraction (pRBf) for Cambodia.



Note: The detailed reference values are presented as example in Annex 1 while the final results in terms of fNRB are presented in tabular and graphic form in Annex 2. Negative values of pRBf indicate that harvesting is larger than the sustainable wood supply.

Step 2: Estimation of the "minimum fraction of Non-Renewable Biomass" (mfNRB)

The "*minimum* fraction of Non-Renewable Biomass" (mfNRB) indicates the best possible situation, given the estimated level of harvesting and the sustainable supply potential of the area under consideration, and assuming the rational management of biomass resources. It is assumed that the harvesting is as sustainable as possible, which means using only the sustainable increment or, in case that the estimated harvesting is greater than the supply potential, using the sustainable increment entirely.

The minimum fraction of Non-Renewable Biomass (mfNRB) for a given area is derived from the pRBf, as follows:

(2) Minimum fNRB (mfNRB) = pRBf * (-1) * 100 (for negative values of pRBf)
= 0 (for positive values of pRBf)

Step 3: Estimation of the Sustainable Increment Exploitation Fraction (SIEF)

The pRBf and mfNRB assume rational harvesting practices, which may be quite different from those actually implemented in the field. For example, if the natural increment is neglected and the exploitation is entirely unsustainable, the true fNRB is 100% even in a biomass-rich area. On the opposite, if the entire sustainable increment is exploited before touching the forest capital, the true fNRB shows the lowest possible value, which corresponds to the value of mfNRB (formula 2).

The true Renewable Biomass fraction (RBf), and hence the true fNRB, depend on how rationally the production of fuelwood and charcoal is conducted. In other terms, they depend on what fraction of the territory non-sustainable harvesting is taking place or, ultimately, what fraction of the sustainable productivity is actually exploited.

If we know that the whole sustainable productivity of the area under consideration is exploited, the true RBf will be equal to pRBF and the true fNRB will be equal to mfNRB.

As the latter situation is very seldom the case, to get to the most likely or "expected" fNRB, without field evidence, we propose to use what we may call the Sustainable Increment Exploitation Fraction (SIEF), for a given area.

SIEF indicates how rational and efficient is the harvesting in the area concerned. SIEF is not telling how much of the increment is actually exploited but how rationally the exploitation is carried out. Its value ranges between 0 (none of the sustainable increment is exploited, the exploitation is totally irrational) and 1 (the sustainable increment is exploited entirely before overexploitation takes place).

Some basic assumptions can be made in relation to the SIEF:

- Over a sizeable geographic region, SIEF values of 1 or 0 are extremely unlikely.
- In the local supply/demand context of rural areas the SIEF is relatively high, especially where the pressure from woodfuel users is high. For these areas SIEF value may range between 0.5 and 1, and a midpoint of 0.75 may be considered a first best estimate.
- For forest areas located in uninhabited or sparsely populated areas (USPA), whose exploitation serves primarily urban markets, the SIEF range is extremely variable but in general much lower

than around rural settlements. For these areas SIEF value may range between 0.25 and 0.75, with a midpoint tentatively put at 0.5.

- Only within urban areas, which are usually small, densely populated and with few biomass resources accessible for harvesting, a SIEF of 1 may be considered.

The SIEF values should be refined on the basis of field knowledge and adapted country by country. In this respect, it will be necessary to identify specific indicators that may guide in the definition of reliable SIEF values, such as, for instance, information on the status of forest management in the countries.[10]

Step 4: Estimation of the "expected Renewable Biomass fraction" (eRBf)

In absence of direct field evidence on the harvesting methods actually applied in the field, the *expected* Renewable Biomass fraction (eRBf) is estimated by applying the SIEF to the potential Renewable Biomass Fraction (pRBf), as per formula (3):

(3) ***expected* Renewable Biomass fraction (eRBf)** (of a given administrative unit) **=**

(<USPA_supply*USPA_SIEF + rural_supply*rural_SIEF + urban_supply*urban_SIEF> - <harvesting>) / <harvesting>

where SIEF is tentatively estimated at = 0.75 for rural areas; 0.5 for uninhabited or sparsely populated areas (USPA) and 1 for urban areas.

Step 5: Estimation of the "expected fraction of Non-Renewable Biomass" (efNRB)

Finally, the <u>*expected*</u> <u>fraction of Non-Renewable Biomass</u> (efNRB) for a given area is derived from the eRBf, as follows (formula 4):

(4) Expected fNRB (efNRB) = eRBf * (-1) * 100 (for negative values of eRBf)

= 0 (for positive values of eRBf)

[10] FAO produced country-wise statistics on the status of forest management as part of the Global Forest Resources Assessment (GFRA)of 2000 but developing counties' data was incomplete and subsequent GFRA editions no longer attempted to provide forest management statistics.

Uncertainty ranges

Due to the lack of a single reliable data source on woody biomass productivity and woodfuel consumption, the original WISDOM studies required the integration of information coming from a wide variety of sources, including data of undetermined reliability, and the assumption of subjective estimates to fill specific data gaps. The variety and heterogeneity of source data prevent the statistical estimation of the accuracy of results and confidence intervals.

In partial alternative of the confidence interval, the probable range of fNRB values may be derived from the value ranges of some key parameters as reported in the original WISDOM studies.

However, this issue requires further analysis and for the time being the results presented in Annex 2 are valid for the medium productivity and consumption levels and should be considered as mid-range estimates.

Example of minimum and expected fNRB for the case of Cambodia

Following on the case study used to exemplify the analytical steps (see Figure 1 above and the example reported in Annex 1), Figure 2 illustrates the geographical distribution of mfNRB and efNRB for the case of Cambodia, and Table 1 shows the specific values of these parameters at the sub-national level.

The graph and the table also represent the final products of the proposed method of analysis, and illustrate the information that project developers will refer to in order to determine the default fNRB for their specific area of interest.

Examining Figure 2 it is readily obvious the large geographical variation in the values of efNRB in Cambodia, from clusters of “provinces” showing high efNRB values in the areas surrounding the Capital of Phnom Penh in the south and in north-western provinces, to provinces with eFNRB values of 0% mostly in the Northern part of the country.

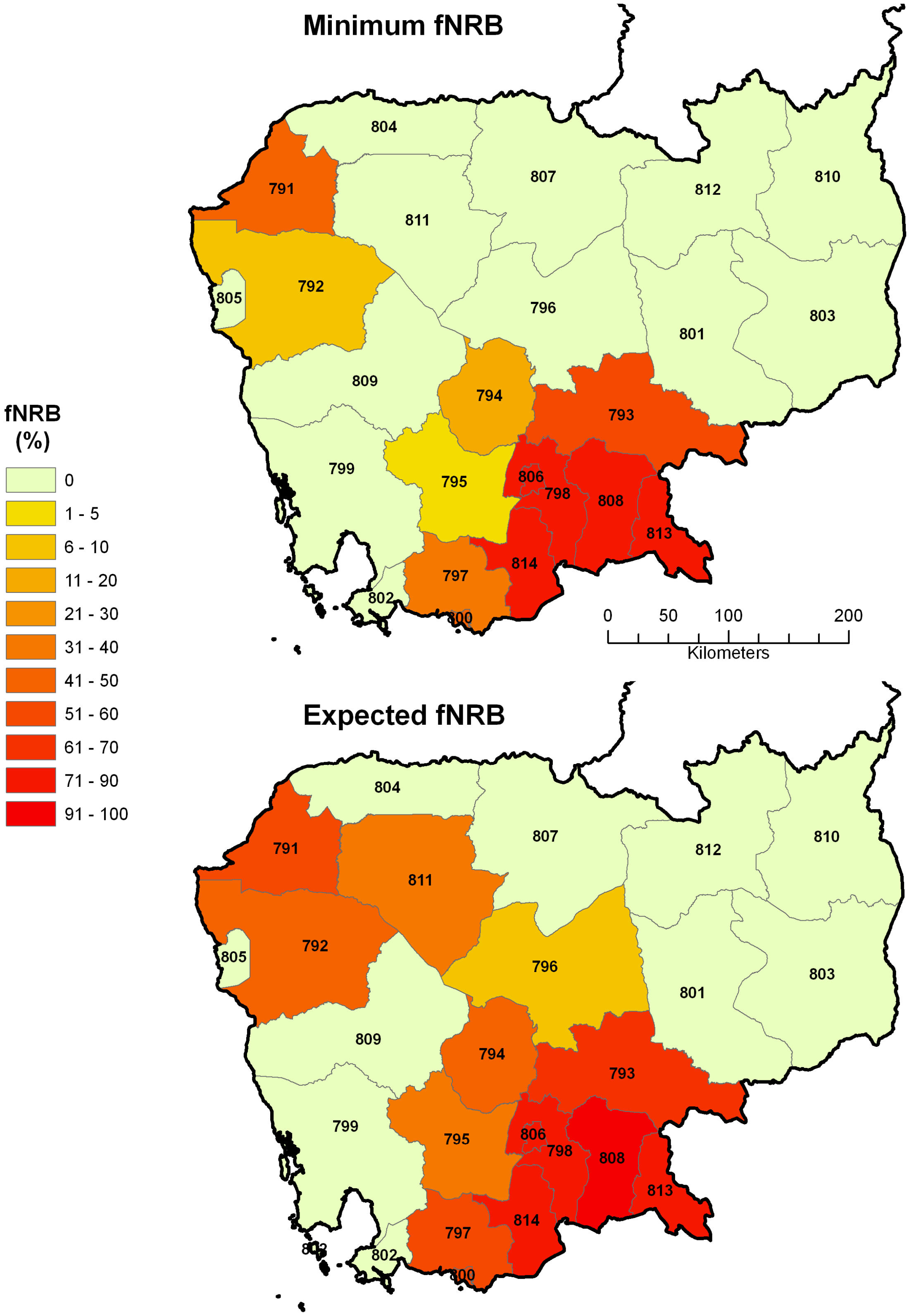
Project developers will then be encouraged to focus their implementation strategy to the areas showing larger values of efNRB, maximizing simultaneously the effectiveness of the intervention in terms of climate change mitigation.

These results confirm that the overall country fNRB of 48% is a very poor predictor of what the actual situation at the sub-national level may be. It should be noted that this geographical heterogeneity of fNRB is present in almost all the countries analyzed, even those with very large reliance on woodfuels such as Chad or Tanzania.

Table 1: Cambodia
Reference year: 2015. Mid-range estimates.

g06_1	Subnational Unit	Minimum fNRB (mfNRB)	Expected fNRB
791	Banteay Meanchey	**41.9**	**57.1**
792	Battambang	**5.0**	**40.2**
793	Kampong Cham	**52.2**	**66.0**
794	Kampong Chhnang	**16.3**	**41.4**
795	Kampong Speu	**2.9**	**38.8**
796	Kampong Thom	0.0	**7.5**
797	Kampot	**35.5**	**55.7**
798	Kandal	**78.1**	**83.2**
799	Koh Kong	0.0	0.0
800	Kop	**42.2**	**57.5**
801	Kratie	0.0	0.0
802	Krong Preah Sihanouk	0.0	0.0
803	Mondul Kiri	0.0	0.0
804	Oddar Meanchey	0.0	0.0
805	Pailin	0.0	0.0
806	Phnom Penh	**80.9**	**82.1**
807	Preah Vihear	0.0	0.0
808	Prey Veng	**86.7**	**90.1**
809	Pursat	0.0	0.0
810	Rattanak Kiri	0.0	0.0
811	Siem Reap	0.0	**35.9**
812	Stung Treng	0.0	0.0
813	Svay Rieng	**77.5**	**83.1**
814	Takeo	**80.1**	**85.0**
	Cambodia Total	**34.0**	**48.4**

Figure 2: Cambodia – Minimum and Expected fNRB



3. Proposed process of analysis and suitable data sources for the systematic estimation of sub-national fNRB based on the WISDOM model

The WISDOM model applied to global public data sets can be used to produce default sub national values of the *expected* fraction of Non Renewable Biomass (efNRB) through transparent, objective and systematic analytical process.

The proposed procedure implies the creation of geo-referenced data on the sustainable woody biomass supply potential, woodfuel consumption and related harvesting levels, which are necessary for the estimation of the fNRB at sub-national and national levels.

It must be emphasized that ready-made data on supply potential and harvesting do not exist and that statistical and GIS processing typical of WISDOM analyses are required for their creation.

3.3 Analytical steps

The proposed approach involves two main steps:

a- The definition of the sustainable supply of woody biomass physically and legally accessible woodfuels consumption in urban areas, rural settlements and sparse rural areas, to be performed using the standard WISDOM model; and

b- the estimation of the expected fNRB default values (efNRB), to be performed using the step-wise procedure described in Section 2.

Estimation of the sustainable wood supply and woodfuel consumption using the WISDOM model

In synthesis, the WISDOM methodology may be divided into two sequential phases/contexts of analysis:

1 - **WISDOM Base**. This phase include the analysis over the entire territory of the study area.

2 - **Woodshed[11] analysis**. This second phase of the analysis uses the result of the WISDOM Base to delineate the sustainable supply zone of selected consumption sites. Depending on the scale and objectives of analysis, the selected sites could be urban centers, rural villages or existing/planned biomass plants.

The specific steps of analysis are summarized below while a graphic overview is shown in Figure 2.

<u>WISDOM Base</u>

The application of the standard WISDOM analysis producing supply and demand balance mapping at the local level involves five main steps (FAO, 2003b).

1. Definition of the administrative reporting units and of the *spatial* unit of analysis.
2. Development of the *demand* module.
3. Development of the *supply* module.

[11] The term "woodshed" is a neologism inspired by the familiar geographic concept of *water*shed. It is used to indicate the portion of the territory necessary to supply on a sustainable basis the woody biomass needed by a specific consumption site.

4. Development of the *integration* module.
5. Selection of the *priority* areas or woodfuel "hot spots" under different scenarios.

Woodshed analysis

The analysis for the delineation of woodsheds, i.e. supply zones of specific consumption sites requires additional analytical steps that may be summarized as follows.

6. Mapping of potential "commercial" woodfuel supplies suitable for urban, peri-urban and rural markets.
7. Definition of woodshed, or potential sustainable supply zones, based on woody biomass production potentials, physical accessibility and woodfuel consumption size of individual urban centers.

In our case the woodshed analysis will be done starting from the major cities of each country with the scope of better assessing the harvesting areas feeding urban woodfuel markets.[12]

Estimation of the expected sub national and national fNRB values

Once the above steps are completed, the estimation of the expected sub national and national fNRB values will be done through the step-wise process of analysis described in Section 2.

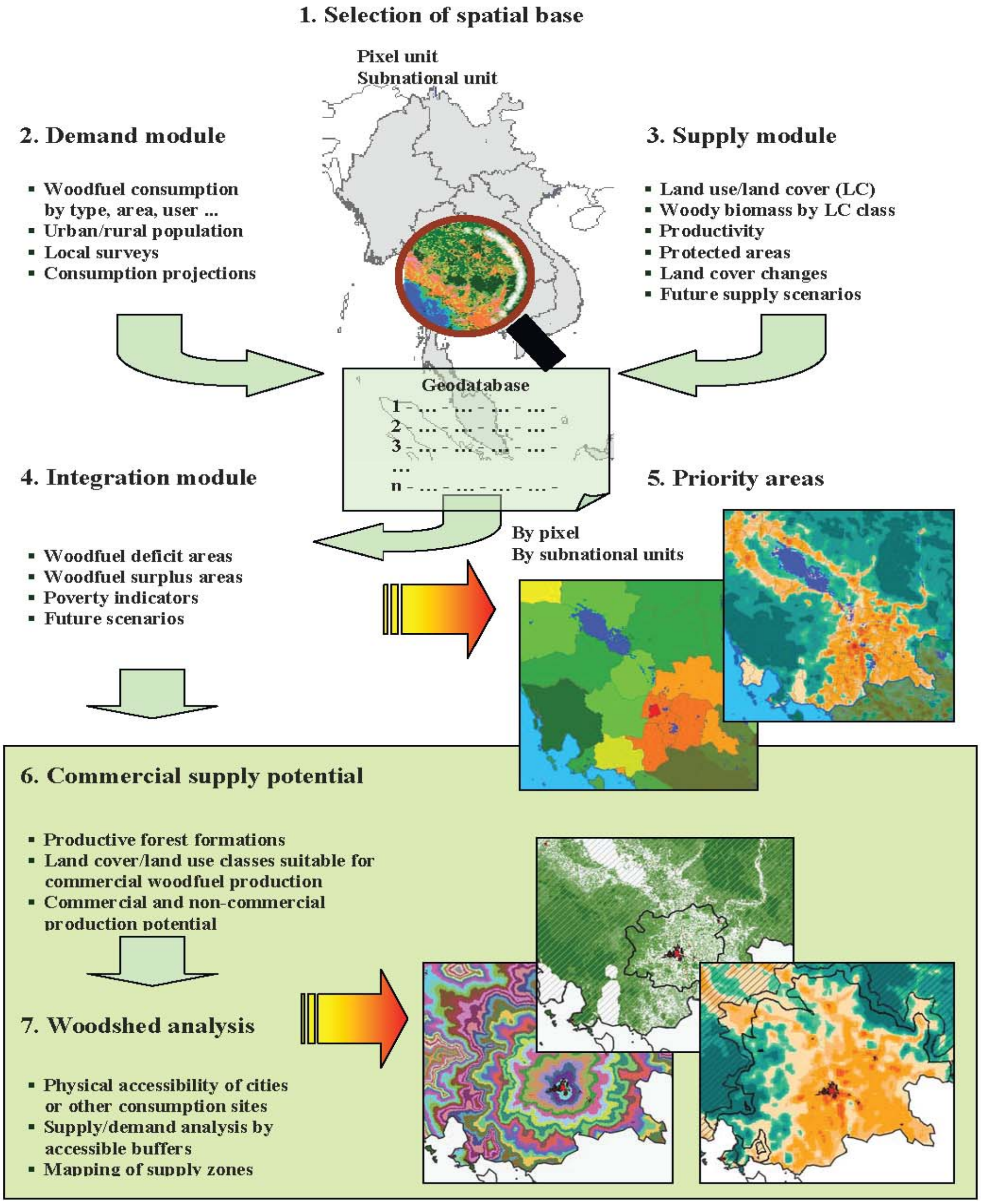
Considering the data layers listed in the following sections, the analysis could be done with a spatial resolution (raster cell size) of 30 arc-second (approximately 1000 m at 0 Lat.). The reporting unit of the expected fNRB will be the 1st sub national administrative level (or 2nd level for larger countries).

The result will be presented as simple tables reporting the efNRB default values at sub national unit level and aggregated at country level. The same elements will be presented also in cartographic form in order to facilitate the location of project areas and the definition of the relevant default values. Users will only need to consult these final tables and maps, as it occurs with other default coefficients such as default emissions factors, etc.

The public cartographic and statistical information that can be used for the implementation of WISDOM analysis and for the systematic estimation of the expected fNRB are listed in the following sections.

[12] The woodshed analysis will be further developed in order to meet more efficiently the scope of fNRB assessment.

Figure 2: WISDOM analytical steps. WISDOM Base (steps 1 to 5) and Woodshed analysis (steps 6, 7)



3.1 Global data sets relevant to the estimation of the Supply potential

Geo-referenced data layers

- **Global land cover mapping**, such as the version 2009 of the Globcover dataset at 10 arc.second resolution (300 m at 0 Lat.) produced by ESA (Bicheron et al., Arino et al.2007) Source data: © ESA / ESA GlobCover Project, led by MEDIAS-France).

- **Global ecological data**, such as the Global Ecological Zone (GEZ) Map produced by FAO in the framework of the 2000 Global Forest Resources Assessment Programme, in collaboration with UNEP-WCMC and USGS Eros Data Center.

- **Global vegetation density data,** such as the Regional Tree Cover maps based on the Vegetation Continuous Field (VCF) algorithm applied to Moderate Resolution Imaging Spectroradiometer (MODIS) multiseasonal data (Hansen et al., 2003). This data has a spatial resolution of 15 arc-second (approx. 500-m at 0 Lat.).

- **Geo-referenced data on biomass stock and productivity** derived from National Forest Inventories and other compiled databases (Baccini et al. 2008; Olson and Gibbs, several references, Brown et al. 2001; Teobaldelli, 2008; Cannell, 1982)

- **Global accessibility data**, such a the map of the estimated travel time to the nearest city of 50,000, or more people in year 2000, produced by the Global Environment Monitoring Unit - Joint Research Centre of the European Commission, Ispra Italy (Nelson, A. .2008). The data are in geographic projection with a resolution of 30 arc seconds (approximately 1 km at 0 Lat.).

- **World Database on Protected Areas (WDPA)**. The WDPA is a joint product of UNEP and IUCN, prepared by UNEP-WCMC, supported by IUCN WCPA and working with Governments, the Secretariats of MEAs and collaborating NGOs.

3.2 Global data sets relevant to the estimation of biomass consumption and harvesting

- **GLOBAL Gridded Population Maps and Data**. Gridded Population of the World, version 3 (GPWv3) and the Global Rural-Urban Mapping Project (GRUMP) are the latest developments in the rendering of human populations in a common geo-referenced framework, produced by the Center for International Earth Science Information Network (CIESIN) of the Earth Institute at Columbia University. The GPWv3 edition includes a gridded population projection to 2015 produced by CIESIN and CIAT in collaboration with the Food and Agriculture Organization of the United Nations (FAO). These maps are produced with a resolution of 30 arc-seconds (approximately 1 km at 0 Lat.).

- **Global administrative unit data**. Sub national subdivisions of 1st and 2n level will be used to report fNRB results.

Statistical sources

- **International databases of forestry and energy statistics**. Such as:
    - FAO country data FAOSTAT
    - FAO Global Forest Products Outlook Study
    - International Energy Agency (IEA) Renewable Energy statistics
    - EUROSTAT
    - Historical references (ENDA/IEPE, ESMAP, FUNBAR, LBL, OLADE, FAO/RWEDP, etc.)
- **Country reports**

The reliability of wood energy statistics is known to be very poor and the discrepancies among data sources can be remarkably wide (FAO 2005). The political attention on the use of woody biomass is increasing and international/national energy and forestry agencies are progressively improving the quality of woodfuel consumption data. Nonetheless the identification of reliable and authoritative references remains a challenging task. For this, it is recommended to harmonize and structure all main data sources in a database allowing a consistent and immediate comparison of data sources. A similar county-wise database was produced by FAO (i-WESTAT, FAO, 2005) and an update of such database is strongly recommended.

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Annex 1. Example of calculation for Cambodia

See the cartographic layers shown in Figure 1

Input data

code	Adm Unit	Sustainable and accessible woody biomass supply potential (tons)				Original consumption values (tons)				Estimated harvesting based on the distribution of urban consumption in neighboring units (colored) proportionally to the supply potential (tons)			
		USPA	Urban	Rural	Total	USPA	Urban	Rural	Total	USPA	Urban	Rural	Total
791	Banteay Meanchey	11,469	1,386	206,206	219,061	1,652	11,138	312,420	325,210	4,937	397	371,477	376,810
792	Battambang	257,110	919	274,036	532,065	15,294	51,446	392,463	459,202	88,929	263	470,946	560,138
793	Kampong Cham	73,584	1,918	384,793	460,295	5,320	23,783	826,138	855,241	26,394	549	936,341	963,285
794	Kampong Chhnang	51,267	147	204,513	255,926	3,466	2,383	229,099	234,948	18,148	42	287,671	305,861
795	Kampong Speu	211,975	0	230,548	442,523	7,473	0	321,432	328,905	68,182	0	387,460	455,642
796	Kampong Thom	733,354	171	230,751	964,276	20,199	3,990	287,079	311,268	230,229	49	353,165	583,443
797	Kampot	50,099	69	148,277	198,445	3,328	79	247,515	250,923	17,676	20	289,981	307,677
798	Kandal	393	9,158	120,025	129,576	32	192,042	555,601	747,675	144	2,623	589,976	592,743
799	Koh Kong	1,607,641	3,449	166,858	1,777,948	19,534	3,074	47,337	69,945	19,534	3,074	47,337	69,945
800	Kop	649	0	9,701	10,350	49	0	17,852	17,901	49	0	17,852	17,901
801	Kratie	762,433	235	353,280	1,115,948	24,116	38	118,402	142,557	24,116	38	118,402	142,557
802	Krong Preah Sihanouk	40,642	3,320	102,149	146,112	1,310	19,015	51,158	71,483	12,950	951	80,413	94,314
803	Mondul Kiri	971,215	0	21,259	992,474	13,887	0	4,855	18,742	13,887	0	4,855	18,742
804	Oddar Meanchey	305,502	0	130,531	436,033	13,263	0	32,162	45,425	13,263	0	32,162	45,425
805	Pailin	66,055	1,171	25,049	92,275	1,826	5,385	18,616	25,827	20,744	335	25,790	46,869
806	Phnom Penh	0	5,707	2,020	7,727	0	1,066,140	38,233	1,104,373	0	1,634	38,812	40,446
807	Preah Vihear	934,853	0	161,077	1,095,930	35,211	0	31,630	66,841	35,211	0	31,630	66,841
808	Prey Veng	0	57	69,383	69,440	0	1,097	504,017	505,114	0	16	523,888	523,904
809	Pursat	765,767	0	160,605	926,372	14,719	0	179,681	194,400	234,032	0	225,678	459,710
810	Rattanak Kiri	562,299	1,040	105,094	668,433	26,269	4,419	28,302	58,989	26,269	4,419	28,302	58,989
811	Siem Reap	278,815	3,661	234,046	516,522	16,529	76,184	332,961	425,673	96,380	1,048	399,991	497,420
812	Stung Treng	992,079	0	63,413	1,055,491	18,594	0	24,025	42,618	18,594	0	24,025	42,618
813	Svay Rieng	607	383	57,765	58,754	198	8,362	244,118	252,678	372	110	260,662	261,143
814	Takeo	0	705	86,289	86,994	0	1,400	411,895	413,295	0	202	436,608	436,810
	Cambodia total	8,677,808	33,494	3,547,668	12,258,970	242,267	1,469,975	5,256,990	6,969,233	970,040	15,771	5,983,422	6,969,233
					5,106,363		1,462,444						

Calculation of renewable biomass

								0.5	1	0.75	=Sustainable Increment Exploitation Fraction		
		potential Renewable Biomass fraction (pRBf)				Minimum fNRB (mfNRB)		EXPECTED Renewable fraction (eRBf)				EXPECTED fNRB (efNRB)	
code	Adm Unit	USPA	Urban	Rural	Adm_tot	Rural	Adm_tot	USPA	Urban	Rural	Adm_tot	Rural	Adm_tot
791	Banteay Meanchey	1.32	2.49	-0.44	-0.42	44.5	41.9	0.16	2.49	-0.58	-0.57	58.4	57.1
792	Battambang	1.89	2.49	-0.42	-0.05	41.8	5.0	0.45	2.49	-0.56	-0.40	56.4	40.2
793	Kampong Cham	1.79	2.49	-0.59	-0.52	58.9	52.2	0.39	2.49	-0.69	-0.66	69.2	66.0
794	Kampong Chhnang	1.82	2.49	-0.29	-0.16	28.9	16.3	0.41	2.49	-0.47	-0.41	46.7	41.4
795	Kampong Speu	2.11	-	-0.40	-0.03	40.5	2.9	0.55	-	-0.55	-0.39	55.4	38.8
796	Kampong Thom	2.19	2.49	-0.35	0.65	34.7	0.0	0.59	2.49	-0.51	-0.07	51.0	7.5
797	Kampot	1.83	2.49	-0.49	-0.36	48.9	35.5	0.42	2.49	-0.62	-0.56	61.6	55.7
798	Kandal	1.72	2.49	-0.80	-0.78	79.7	78.1	0.36	2.49	-0.85	-0.83	84.7	83.2
799	Koh Kong	81.30	0.12	2.52	24.42	0.0	0.0	40.15	0.12	1.64	12.33	0.0	0.0
800	Kop	12.26	-	-0.46	-0.42	45.7	42.2	5.63	-	-0.59	-0.58	59.2	57.5
801	Kratie	30.61	5.13	1.98	6.83	0.0	0.0	14.81	5.13	1.24	3.53	0.0	0.0
802	Krong Preah Sihanouk	2.14	2.49	0.27	0.55	0.0	0.0	0.57	2.49	-0.05	0.06	4.7	0.0
803	Mondul Kiri	68.94	-	3.38	51.95	0.0	0.0	33.97	-	2.28	25.76	0.0	0.0
804	Oddar Meanchey	22.03	-	3.06	8.60	0.0	0.0	10.52	-	2.04	4.52	0.0	0.0
805	Pailin	2.18	2.49	-0.03	0.97	2.9	0.0	0.59	2.49	-0.27	0.13	27.2	0.0
806	Phnom Penh	-	2.49	-0.95	-0.81	94.8	80.9	-	2.49	-0.96	-0.82	96.1	82.1
807	Preah Vihear	25.55	-	4.09	15.40	0.0	0.0	12.28	-	2.82	7.80	0.0	0.0
808	Prey Veng	-	2.49	-0.87	-0.87	86.8	86.7	-	2.49	-0.90	-0.90	90.1	90.1
809	Pursat	2.27	-	-0.29	1.02	28.8	0.0	0.64	-	-0.47	0.09	46.6	0.0
810	Rattanak Kiri	20.41	-0.76	2.71	10.33	0.0	0.0	9.70	-0.76	1.79	5.12	0.0	0.0
811	Siem Reap	1.89	2.49	-0.41	0.04	41.5	0.0	0.45	2.49	-0.56	-0.36	56.1	35.9
812	Stung Treng	52.36	-	1.64	23.77	0.0	0.0	25.68	-	0.98	11.76	0.0	0.0
813	Svay Rieng	0.63	2.49	-0.78	-0.78	77.8	77.5	-0.18	2.49	-0.83	-0.83	83.4	83.1
814	Takeo	-	2.49	-0.80	-0.80	80.2	80.1	-	2.49	-0.85	-0.85	85.2	85.0
	Cambodia total	7.95	1.12	-0.41	0.76	53.0	34.0	3.47	1.12	-0.56	0.01	63.3	48.4

Annex 2: fNRB estimates at sub national and national level for 11 countries

Preliminary results for the countries already covered by WISDOM analyses are shown in the following tables and maps.

The countries covered and the relative reference year of estimation are:

Region	Country	Reference year	Reference study
AFR	Burundi	(2000)	FAO, 2006
AFR	Chad	(2009)	Drigo (in press)
AFR	Democratic Republic of the Congo	(2000)	FAO, 2006
AFR	Eritrea	(2000)	FAO, 2006
AFR	Mozambique	(2004)	Drigo, 2008
AFR	Rwanda	(2009)	Drigo and Nzabanita, 2011
AFR	Sudan [analysis still in progress]	(2000)	FAO, 2006
AFR	United Republic of Tanzania	(2000)	FAO, 2006
ASP	Cambodia	(2015 projection)	FAO, 2007
ASP	Lao People's Democratic Republic	(2015 projection)	FAO, 2007
ASP	Myanmar	(2015 projection)	FAO, 2007

Since these results are based on previous independent WISDOM case studies, they present varying reference years and the underlying data are not homogeneous in terms of thematic and spatial details. For this, they should be considered as examples of how WISDOM can support the estimation of default fNRB values.

It should be clear that a new WISDOM analysis conducted with the specific objective of producing default fNRB values for all developing countries (see next section) will be consistent in all respects and country values will be comparable.

Table A2.1: Cambodia

(For Cambodia results see Table 1 in Section 2)

Table A2.2: Lao P.D.R.

Reference year: 2015. Mid-range estimates.

Country	g06_1	Subnational Unit	Minimum fNRB (mfNRB)	Expected fNRB
Lao PDR	1753	Attopu	0.0	0.0
Lao PDR	1754	Bokeo	0.0	0.0
Lao PDR	1755	Bolikhamsai	0.0	0.0
Lao PDR	1756	Champassack	0.0	0.0
Lao PDR	1757	Houaphanh	0.0	0.0
Lao PDR	1758	Khammouane	0.0	0.0
Lao PDR	1759	Luang Prabang	0.0	0.0
Lao PDR	1760	Namtha	0.0	0.0
Lao PDR	1761	Oudomxay	0.0	0.0
Lao PDR	1762	Phongsaly	0.0	0.0
Lao PDR	1763	Saravane	0.0	0.0
Lao PDR	1764	Savannakhet	0.0	0.0
Lao PDR	1765	Sayabouri	0.0	0.0
Lao PDR	1766	Sekong	0.0	0.0
Lao PDR	1767	Vientiane	0.0	0.0
Lao PDR	1768	Vientiane (Munic.)	**60.1**	**72.6**
Lao PDR	1769	Vientiane 2	0.0	0.0
Lao PDR	1770	Xiangkhouang	0.0	0.0
	Lao PDR Total		**10.1**	**12.1**

Table A2.3: Myanmar

Reference year: 2015. Mid-range estimates.

Country	g06_1	Subnational Unit	Minimum fNRB (mfNRB)	Expected fNRB
Myanmar	2123	Arakan (Rakhine)	0.0	0.0
Myanmar	2124	Bago (Pegu)	**0.9**	**42.1**
Myanmar	2125	Chin	0.0	0.0
Myanmar	2126	Irrawaddy	**44.9**	**63.0**
Myanmar	2127	Kachin	0.0	0.0
Myanmar	2128	Kawthulei (Karen)	0.0	0.0
Myanmar	2129	Kayah	0.0	0.0
Myanmar	2130	Magwe	0.0	**8.4**
Myanmar	2131	Mandalay	**32.3**	**57.7**
Myanmar	2132	Mon	**14.8**	**42.7**
Myanmar	2133	Sagaing	0.0	0.0
Myanmar	2134	Shan	0.0	0.0
Myanmar	2135	Tenasserim	0.0	0.0
Myanmar	2136	Yangon (Rangoon)	**47.7**	**59.7**
	Myanmar Total		**14.0**	**29.2**

Figure A2.1: Cambodia – Minimum and Expected fNRB

(For Cambodia maps see Figure 2 in Section 2)

Figure A2.2: Lao D.P.R. – Minimum and Expected fNRB

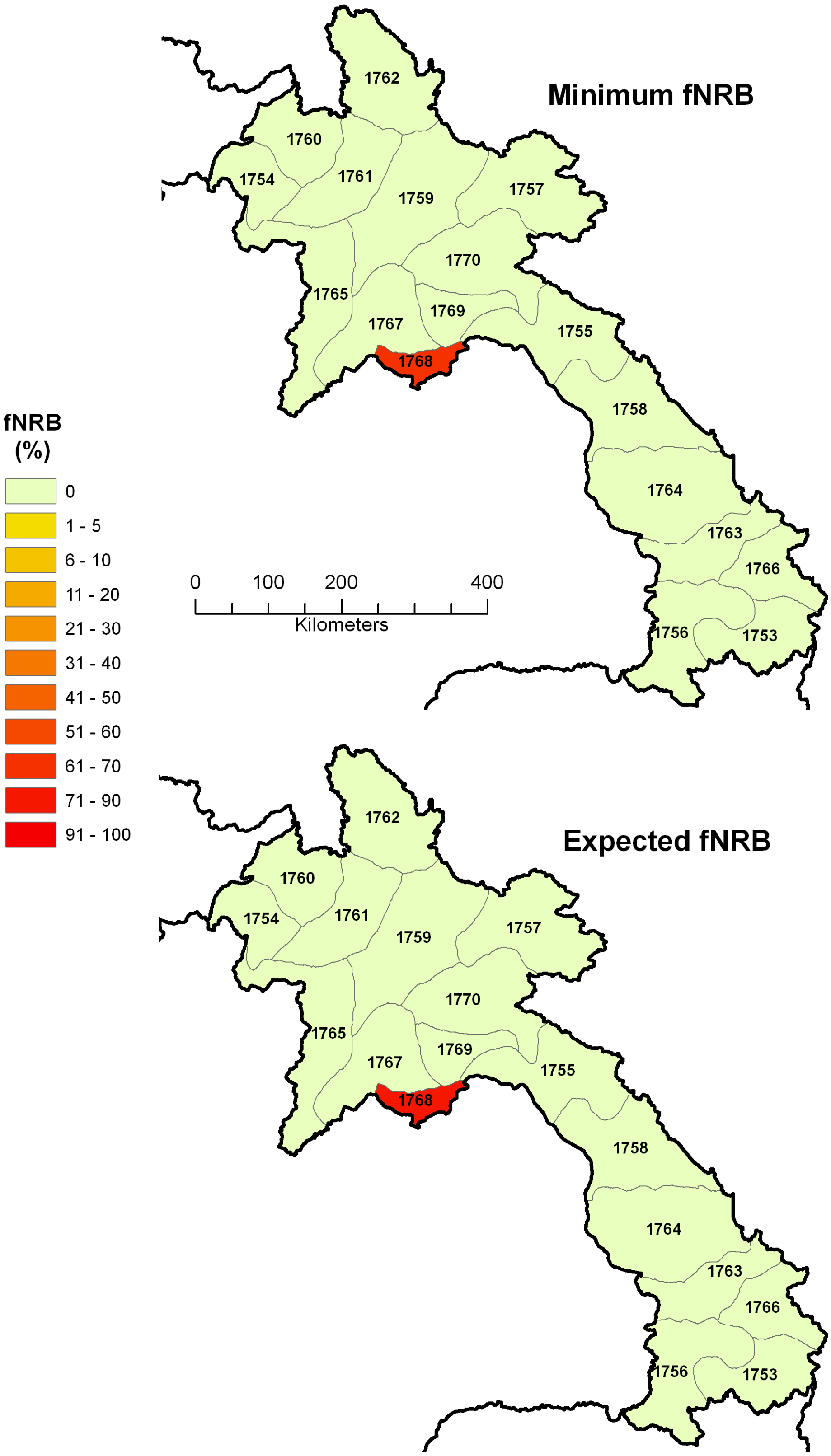


Figure A2.3: Myanmar– Minimum and Expected fNRB

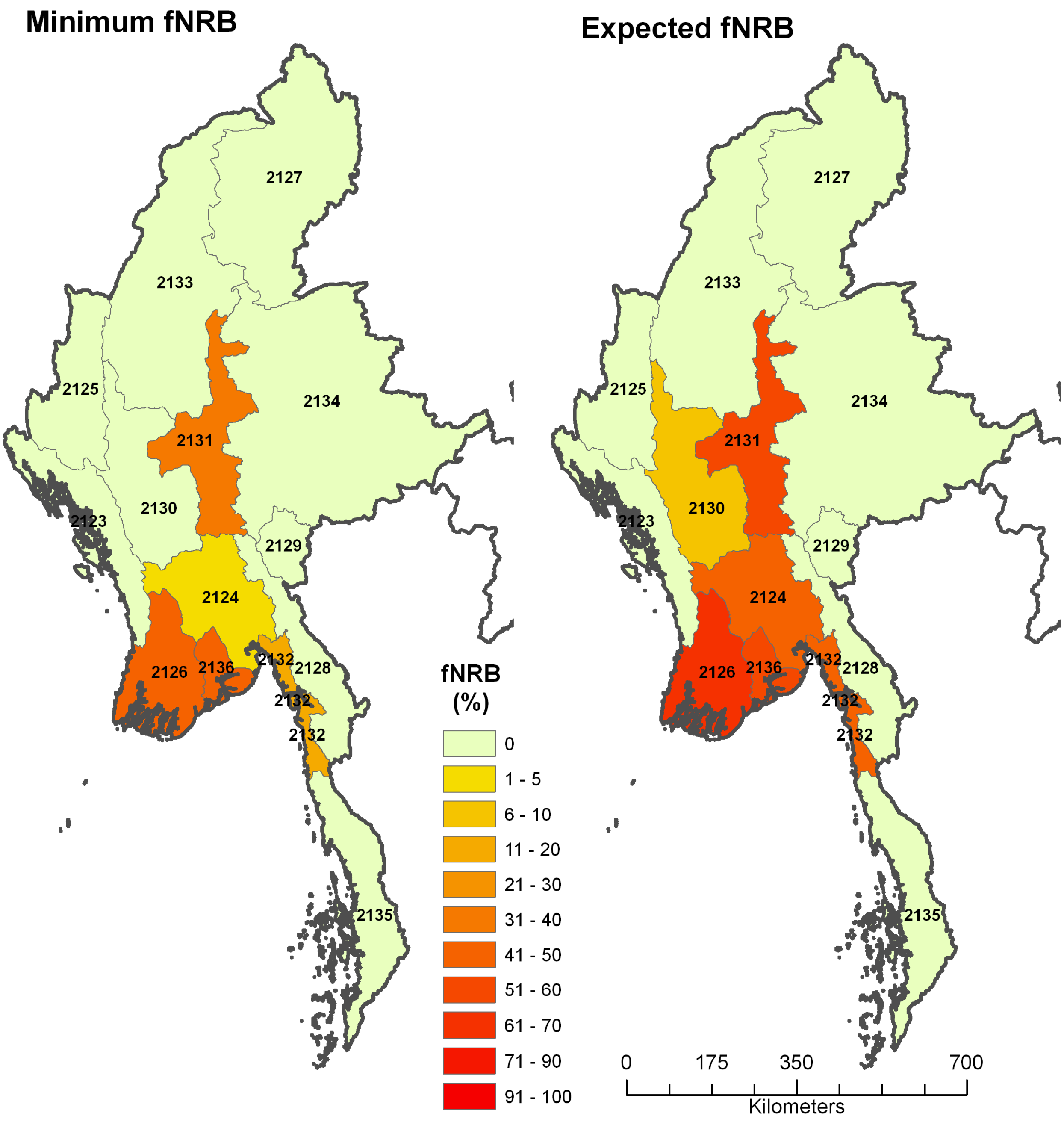


Table A2.4: Chad
Reference year: 2009. Mid-range estimates

Country	g06_1	Subnational Unit	Minimum fNRB (mfNRB)	Expected fNRB
Chad	12904	Batha Est	**11.9**	**38.1**
Chad	12905	Batha Ouest	0.0	0.0
Chad	12906	Biltine	**81.0**	**86.0**
Chad	12907	Borkou	0.0	0.0
Chad	12908	Ennedi	0.0	0.0
Chad	12909	Tibesti	0.0	0.0
Chad	12910	Baguirmi	**0.7**	**30.9**
Chad	12911	Daraba	0.0	0.0
Chad	12912	Hadjer Lamis	**46.2**	**59.6**
Chad	12913	Guera	0.0	0.0
Chad	12914	Barl El Gazal	0.0	0.0
Chad	12915	Kanem	0.0	0.0
Chad	12916	Lac	0.0	0.0
Chad	12917	Logone-occidental	0.0	**3.4**
Chad	12918	Logone-oriental	0.0	0.0
Chad	12919	Mont De Lam	0.0	0.0
Chad	12920	Kabia	**25.4**	**44.0**
Chad	12921	Mayo-boneye	**21.0**	**42.0**
Chad	12922	Mayo-dala	0.0	**1.2**
Chad	12923	Barh Koh	0.0	0.0
Chad	12924	Lac Iro	0.0	0.0
Chad	12925	Mandoul	0.0	0.0
Chad	12926	Assongha	**57.5**	**68.2**
Chad	12927	Ouaddai	0.0	**22.0**
Chad	12928	Sila	0.0	0.0
Chad	12929	Salamat	0.0	0.0
Chad	12930	Tandjile Est	0.0	0.0
Chad	12931	Tandjile Ouest	**20.0**	**40.2**
Chad		**Total**	**11.8**	**23.4**

Figure A2.4: Chad – Minimum and Expected fNRB

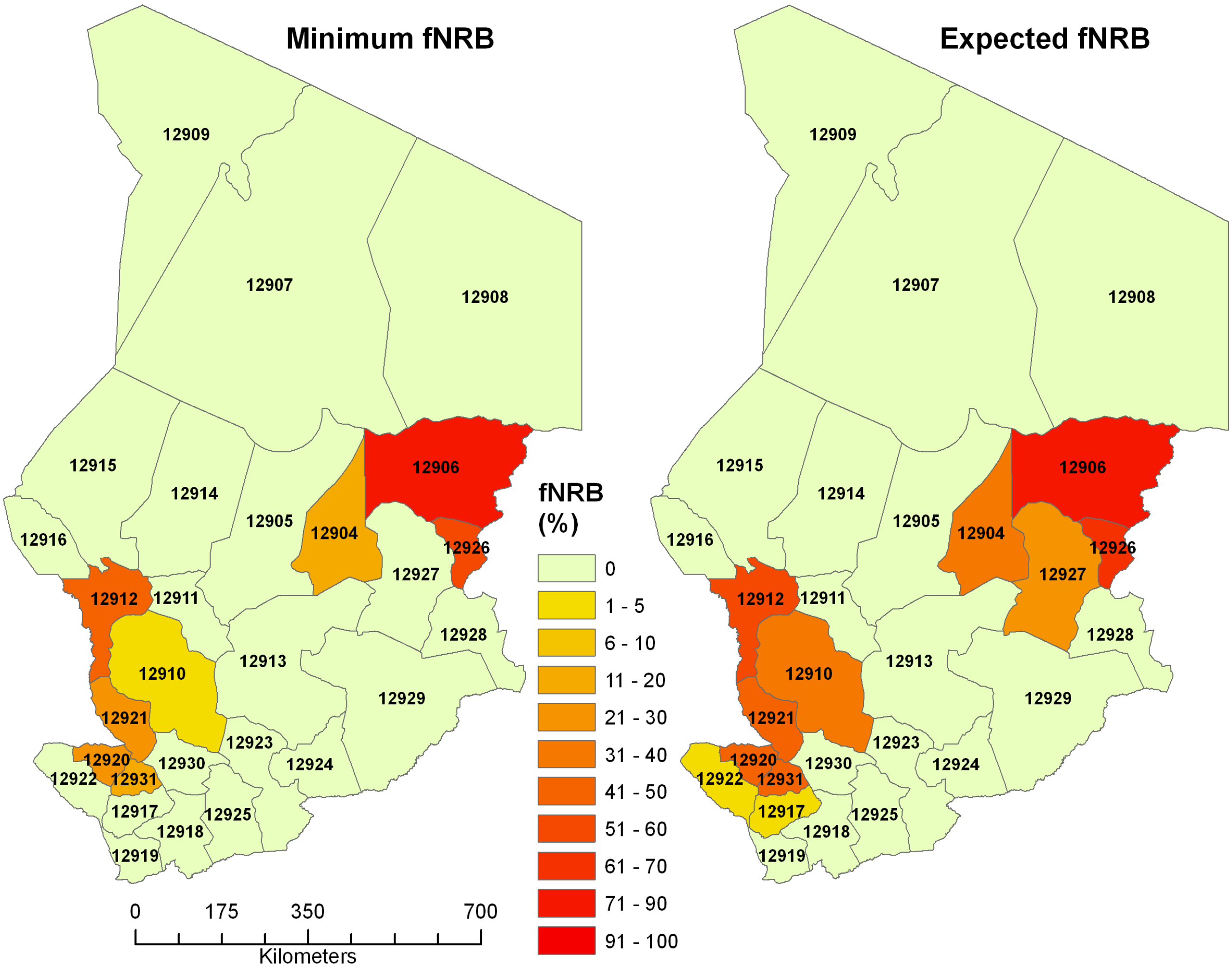


Table A2.5: Rwanda
Reference year: 2006. Mi-range estimates.
Given the diffuse and intense pressure on biomass resources throughout the country, it is reasonable to assume that in case of Rwanda the expected fNRB matches the Minimum fNRB (mfNRB).
is

Country	g06_1	Subnational Unit	Expected fNRB (efNRB) = Minimum fNRB (mfNRB)
Rwanda	2578	Butare	61.1
Rwanda	2579	Byumba	70.6
Rwanda	2580	Cyangugu	64.2
Rwanda	2581	Gikongoro	38.7
Rwanda	2582	Gisenyi	74.9
Rwanda	2583	Gitarama	63.6
Rwanda	2584	Kibungo	65.8
Rwanda	2585	Kibuye	38.9
Rwanda	2586	Kigali-ngali	65.6
Rwanda	2587	Prefecture De La Ville De Kigali	88.4
Rwanda	2588	Ruhengeri	72.9
Rwanda	2589	Umutara	50.3
Rwanda		Total	62.4

Figure A2.5: Rwanda –Expected fNRB (= to mfNRB)

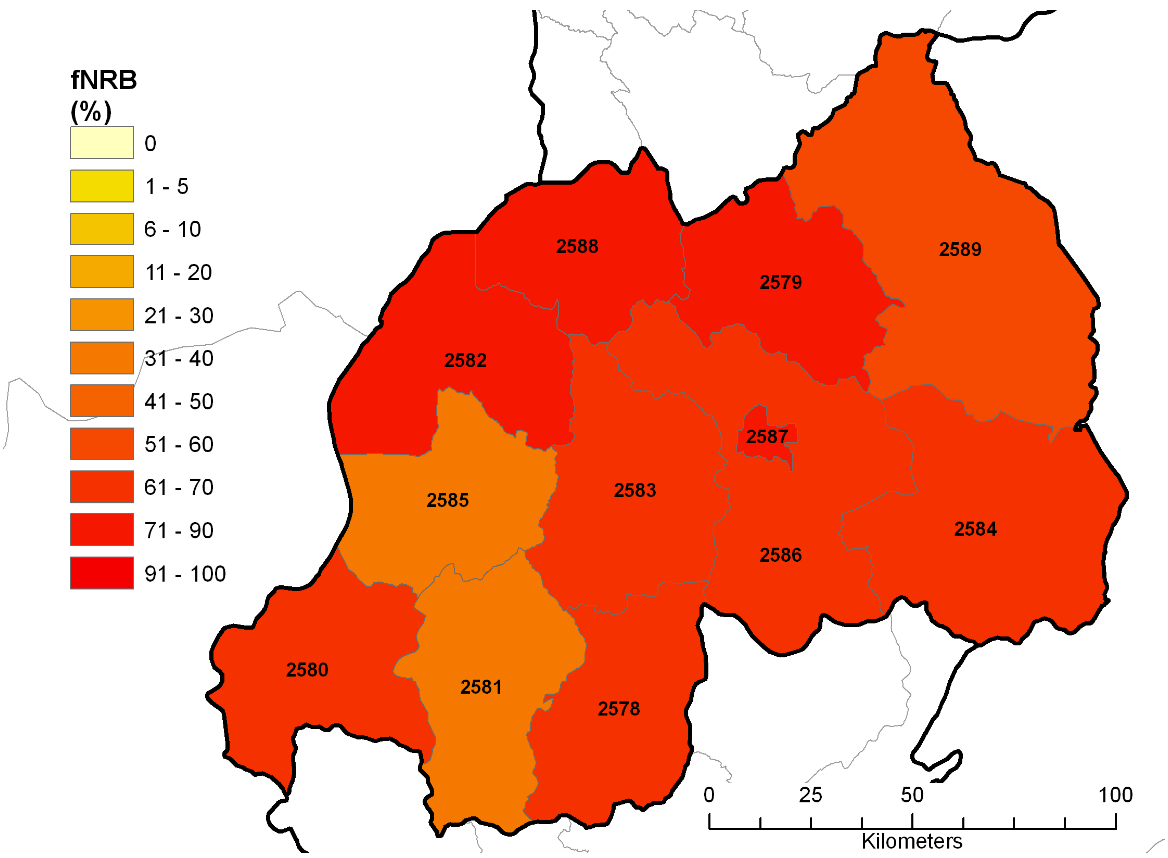


Table A2.6: Mozambique
Reference year: 2004. Mid-range estimates

Country	g06_1	Subnational Unit	Minimum fNRB (mfNRB)	Expected fNRB
Mozambique	21833	Ancuabe	0.0	0.0
Mozambique	21834	Balama	0.0	0.0
Mozambique	21835	Chiure	0.0	0.0
Mozambique	21836	Ibo	37.6	53.2
Mozambique	21837	Macomia	0.0	0.0
Mozambique	21838	Mecufi	11.0	33.2
Mozambique	21839	Meluco	0.0	0.0
Mozambique	21840	Mocimboa da Praia	0.0	0.0
Mozambique	21841	Montepuez	0.0	0.0
Mozambique	21842	Mueda	0.0	0.0
Mozambique	21843	Muidumbe	0.0	0.0
Mozambique	21844	Namuno	0.0	0.0
Mozambique	21845	Nangade	0.0	0.0
Mozambique	21846	Palma	0.0	0.0
Mozambique	21847	Pemba	6.7	29.4
Mozambique	21848	Quissanga	0.0	0.0
Mozambique	21849	Bilene	32.2	47.7
Mozambique	21850	Chibuto	3.8	32.0
Mozambique	21851	Chicualacuala	0.0	0.0
Mozambique	21852	Chigubo	0.0	0.0
Mozambique	21853	Chokwe	39.0	54.1
Mozambique	21854	Guija	0.0	24.3
Mozambique	21855	Mabalane	0.0	23.4
Mozambique	21856	Mandlakazi	18.8	39.1
Mozambique	21857	Massangena	0.0	0.0
Mozambique	21858	Massingir	0.0	10.8
Mozambique	21859	Xai-Xai	56.6	67.0
Mozambique	21860	Funhalouro	0.0	0.0
Mozambique	21861	Govuro	0.0	0.0
Mozambique	21862	Homoine	27.2	42.8
Mozambique	21863	Inharrime	3.3	27.4
Mozambique	21864	Inhassoro	0.0	0.0
Mozambique	21865	Jangamo	30.3	45.5
Mozambique	21866	Mabote	0.0	0.0
Mozambique	21867	Massinga	0.0	0.0
Mozambique	21868	Morrumbene	0.0	23.3
Mozambique	21869	Panda	0.0	16.7
Mozambique	21870	Vilankulo	0.0	0.0
Mozambique	21871	Zavala	30.3	47.7
Mozambique	21872	Barue	0.0	0.0
Mozambique	21873	Gondola	0.0	0.7
Mozambique	21874	Guro	0.0	0.0
Mozambique	21875	Machaze	0.0	0.0
Mozambique	21876	Macossa	0.0	0.0
Mozambique	21877	Manica	0.0	1.2
Mozambique	21878	Mossurize	0.0	0.0
Mozambique	21879	Sussundenga	0.0	0.0
Mozambique	21880	Tambara	0.0	0.0
Mozambique	21881	Maputo (city)	38.8	44.4
Mozambique	21882	Boane	38.7	50.9
Mozambique	21883	Magude	0.0	14.8
Mozambique	21884	Manhica	33.0	49.5
Mozambique	21885	Marracuene	47.8	60.7
Mozambique	21886	Matutuine	0.0	6.8
Mozambique	21887	Moamba	0.0	6.5

(continued)

Country	g06_1	Subnational Unit	Minimum fNRB (mfNRB)	Expected fNRB
Mozambique	21888	Namaacha	0.0	**23.6**
Mozambique	21889	Angoche	0.0	**21.7**
Mozambique	21890	Erati	0.0	0.0
Mozambique	21891	Lalaua	0.0	0.0
Mozambique	21892	Malema	0.0	0.0
Mozambique	21893	Meconta	0.0	0.0
Mozambique	21894	Mecuburi	0.0	0.0
Mozambique	21895	Memba	0.0	0.0
Mozambique	21896	Mogincual	0.0	0.0
Mozambique	21897	Mogovolas	**4.5**	**28.3**
Mozambique	21898	Moma	0.0	**11.9**
Mozambique	21899	Monapo	0.0	0.0
Mozambique	21900	Mossuril	0.0	0.0
Mozambique	21901	Muecate	0.0	0.0
Mozambique	21902	Murrupula	0.0	0.0
Mozambique	21903	Nacala-A-Velha	0.0	0.0
Mozambique	21904	Nacaroa	0.0	0.0
Mozambique	21905	Nampula	0.0	**0.2**
Mozambique	21906	Ribaue	0.0	0.0
Mozambique	21907	Cuamba	0.0	0.0
Mozambique	21908	Lago	0.0	0.0
Mozambique	21909	Lichinga	0.0	0.0
Mozambique	21910	Majune	0.0	0.0
Mozambique	21911	Mandimba	0.0	0.0
Mozambique	21912	Marrupa	0.0	0.0
Mozambique	21913	Maua	0.0	0.0
Mozambique	21914	Mavago	0.0	0.0
Mozambique	21915	Mecanhelas	0.0	0.0
Mozambique	21916	Mecula	0.0	**8.3**
Mozambique	21917	Metarica	0.0	0.0
Mozambique	21918	Muembe	0.0	0.0
Mozambique	21919	N'gauma	0.0	0.0
Mozambique	21920	Nipepe	0.0	0.0
Mozambique	21921	Sanga	0.0	0.0
Mozambique	21922	Buzi	0.0	0.0
Mozambique	21923	Caia	0.0	0.0
Mozambique	21924	Chemba	0.0	0.0
Mozambique	21925	Cheringoma	0.0	0.0
Mozambique	21926	Chibabava	0.0	0.0
Mozambique	21927	Dondo	0.0	**16.5**
Mozambique	21928	Gorongoza	0.0	0.0
Mozambique	21929	Machanga	0.0	0.0
Mozambique	21930	Maringue	0.0	0.0
Mozambique	21931	Marromeu	0.0	0.0
Mozambique	21932	Muanza	0.0	0.0
Mozambique	21933	Nhamatanda	**6.9**	**30.1**
Mozambique	21934	Angonia	**62.0**	**71.5**
Mozambique	21935	Cahora Bassa	0.0	0.0
Mozambique	21936	Changara	0.0	0.0
Mozambique	21937	Chifunde	0.0	0.0
Mozambique	21938	Chiuta	0.0	0.0
Mozambique	21939	Macanga	0.0	0.0
Mozambique	21940	Magoe	0.0	0.0
Mozambique	21941	Maravia	0.0	0.0
Mozambique	21942	Moatize	0.0	0.0
Mozambique	21943	Mutarara	**63.5**	**72.8**
Mozambique	21944	Tsangano	**42.0**	**56.5**

(continued)

Country	g06_1	Subnational Unit	Minimum fNRB (mfNRB)	Expected fNRB
Mozambique	21945	Zumbu	0.0	0.0
Mozambique	21946	Chinde	0.0	0.0
Mozambique	21947	Gile	0.0	0.0
Mozambique	21948	Gurue	0.0	0.0
Mozambique	21949	Ile	0.0	0.0
Mozambique	21950	Inhassunge	**8.8**	**31.6**
Mozambique	21951	Lugela	0.0	0.0
Mozambique	21952	Maganja Da Costa	0.0	0.0
Mozambique	21953	Milange	0.0	0.0
Mozambique	21954	Mocuba	0.0	0.0
Mozambique	21955	Molocue	0.0	0.0
Mozambique	21956	Mopeia	0.0	0.0
Mozambique	21957	Morrumbala	0.0	0.0
Mozambique	21958	Namacurra	0.0	**21.5**
Mozambique	21959	Namaroi	0.0	0.0
Mozambique	21960	Nicoadala	0.0	**15.6**
Mozambique	21961	Pebane	0.0	0.0
Mozambique		Total	**5.1**	**11.6**

Figure A2.6: Mozambique –Minimum fNRB

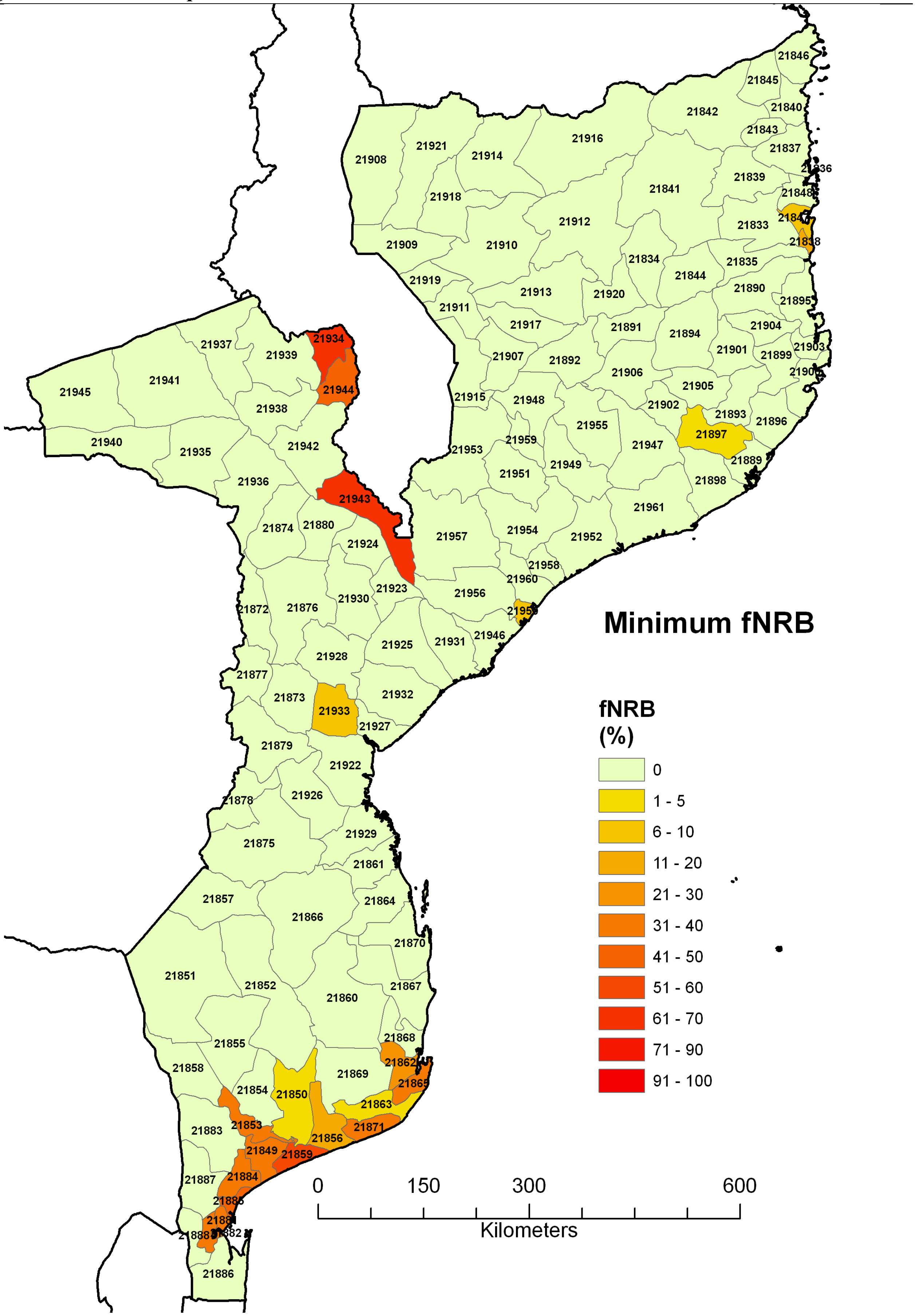


Figure A2.7: Mozambique –Expected fNRB

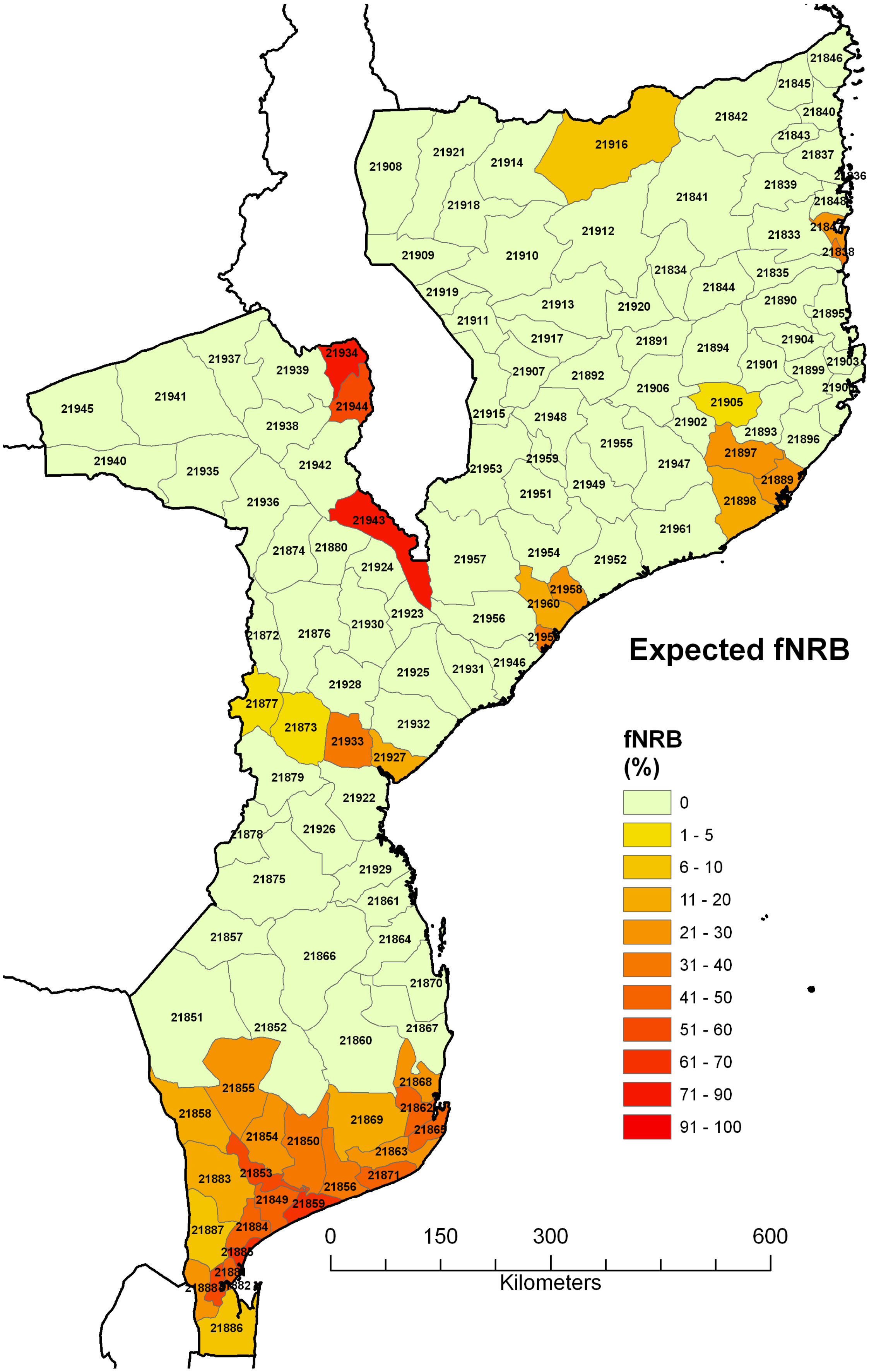


Table A2.7: Eritrea
Reference year: 2000. Mid-range estimates

Country	g06_1	Subnational Unit	Minimum fNRB (mfNRB)	Expected fNRB
Eritrea	1205	Anseba	35.7	57.3
Eritrea	1206	Archipelagos	97.3	98.4
Eritrea	1207	Debub	72.8	79.9
Eritrea	1208	Debubawi Keih Bahri	73.0	85.7
Eritrea	1209	Gash Barka	22.3	47.2
Eritrea	1210	Maekel	88.6	91.1
Eritrea	1211	Semenawi Keih Bahri	28.4	50.9
Eritrea		Total	51.3	66.4

Table A2.8: Burundi
Reference year: 2000. Mid-range estimates

Given the diffuse and intense pressure on biomass resources throughout the country, it is reasonable to assume that in case of Burundi the expected fNRB matches the Minimum fNRB (mfNRB).

Country	g06_1	Subnational Unit	Expected fNRB (efNRB) = Minimum fNRB (mfNRB)
Burundi	40542	Bubanza	70.3
Burundi	40543	Bujumbura-Mairie	98.8
Burundi	40544	Bujumbura-Rural	70.3
Burundi	40545	Bururi	53.1
Burundi	40546	Cankuzo	50.9
Burundi	40547	Cibitoke	35.1
Burundi	40548	Gitega	80.9
Burundi	40549	Karuzi	85.0
Burundi	40550	Kayanza	77.9
Burundi	40551	Kirundo	80.7
Burundi	40552	Makamba	68.3
Burundi	40553	Muramvya	60.1
Burundi	40554	Muyinga	81.7
Burundi	40555	Mwaro	80.4
Burundi	40556	Ngozi	89.9
Burundi	40557	Rutana	61.2
Burundi	40558	Ruyigi	73.5
Burundi		**Total**	73.3

Figure A2.8: Eritrea – Minimum and Expected fNRB

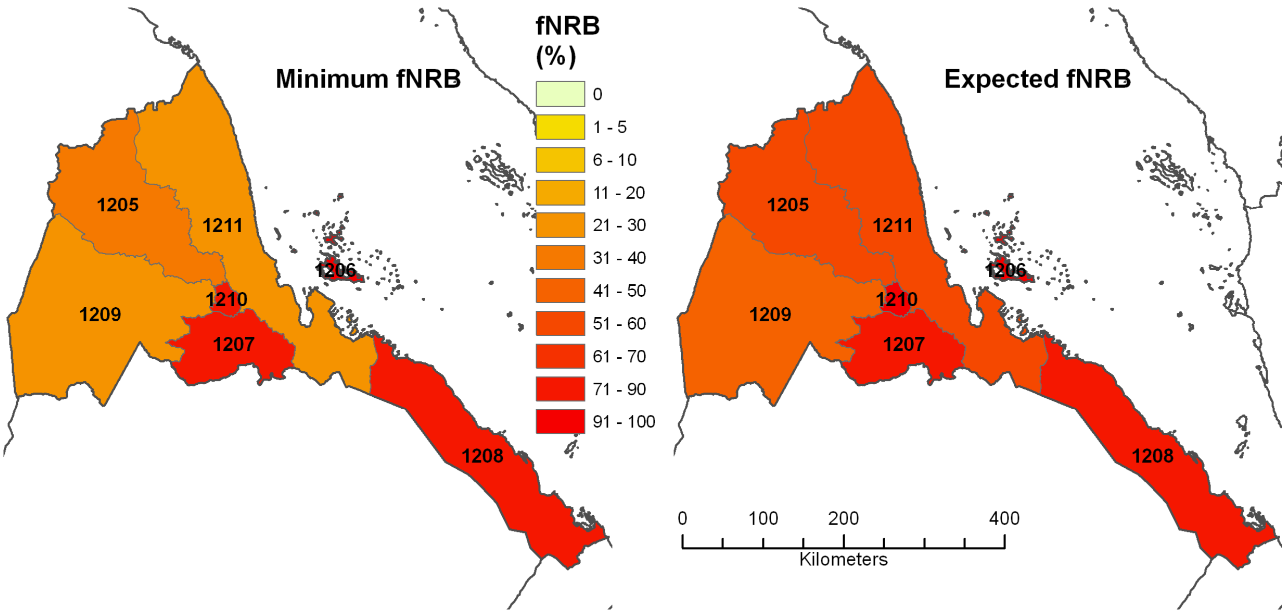


Figure A2.9: Burundi –Expected fNRB (= mfNRB)

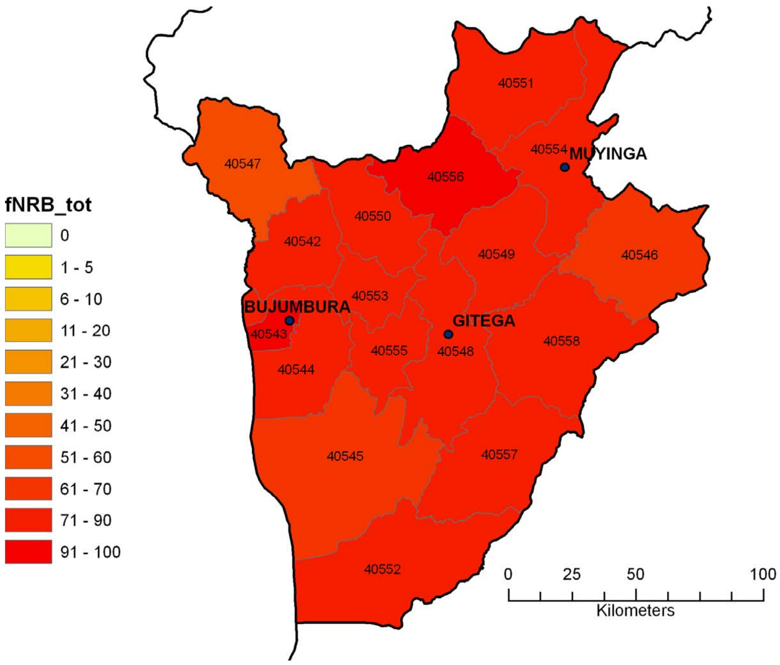


Table A2.9: DRC
Reference year: 2000. Mid-range estimates

Country	g06_1	Subnational Unit	Minimum fNRB (mfNRB)	Expected fNRB
DRC	14959	Bandundu	0.0	0.0
DRC	14960	Kwango	0.0	0.0
DRC	14961	Kwilu	0.0	0.0
DRC	14962	Mai-ndombe	0.0	0.0
DRC	14963	Bas-fleuve	0.0	0.0
DRC	14964	Boma	0.0	0.0
DRC	14965	Cataractes	0.0	0.0
DRC	14966	Lukaya	0.0	**11.6**
DRC	14967	Matadi	0.0	0.0
DRC	14968	Equateur	0.0	0.0
DRC	14969	Mbandaka	0.0	**38.4**
DRC	14970	Mongala	0.0	0.0
DRC	14971	Nord-ubangi	0.0	0.0
DRC	14972	Sud-ubangi	0.0	0.0
DRC	14973	Tshuapa	0.0	0.0
DRC	14974	Kananga	0.0	0.0
DRC	14975	Kasai	0.0	0.0
DRC	14976	Lulua	0.0	0.0
DRC	14977	Kabinda	0.0	0.0
DRC	14978	Mbuji-mayi	0.0	0.0
DRC	14979	Sankuru	0.0	0.0
DRC	14980	Tshilenge	0.0	0.0
DRC	14981	Haut-lomami	0.0	0.0
DRC	14982	Haut-shaba	0.0	0.0
DRC	14983	Kolwezi	0.0	0.0
DRC	14984	Lualaba	0.0	0.0
DRC	14985	Lubumbashi	0.0	0.0
DRC	14986	Tanganika	0.0	0.0
DRC	14987	Kinshasa	0.0	**14.4**
DRC	14988	Maniema	0.0	0.0
DRC	14989	Nord-kivu	0.0	0.0
DRC	14990	Bas-uele	0.0	0.0
DRC	14991	Haut-uele	0.0	0.0
DRC	14992	Ituri	0.0	0.0
DRC	14993	Kisangani	0.0	0.0
DRC	14994	Tshopo	0.0	0.0
DRC	14995	Sud-kivu	0.0	0.0
DRC		**Total**	0.0	**1.6**

Figure A2.10: DRC – Minimum and Expected fNRB

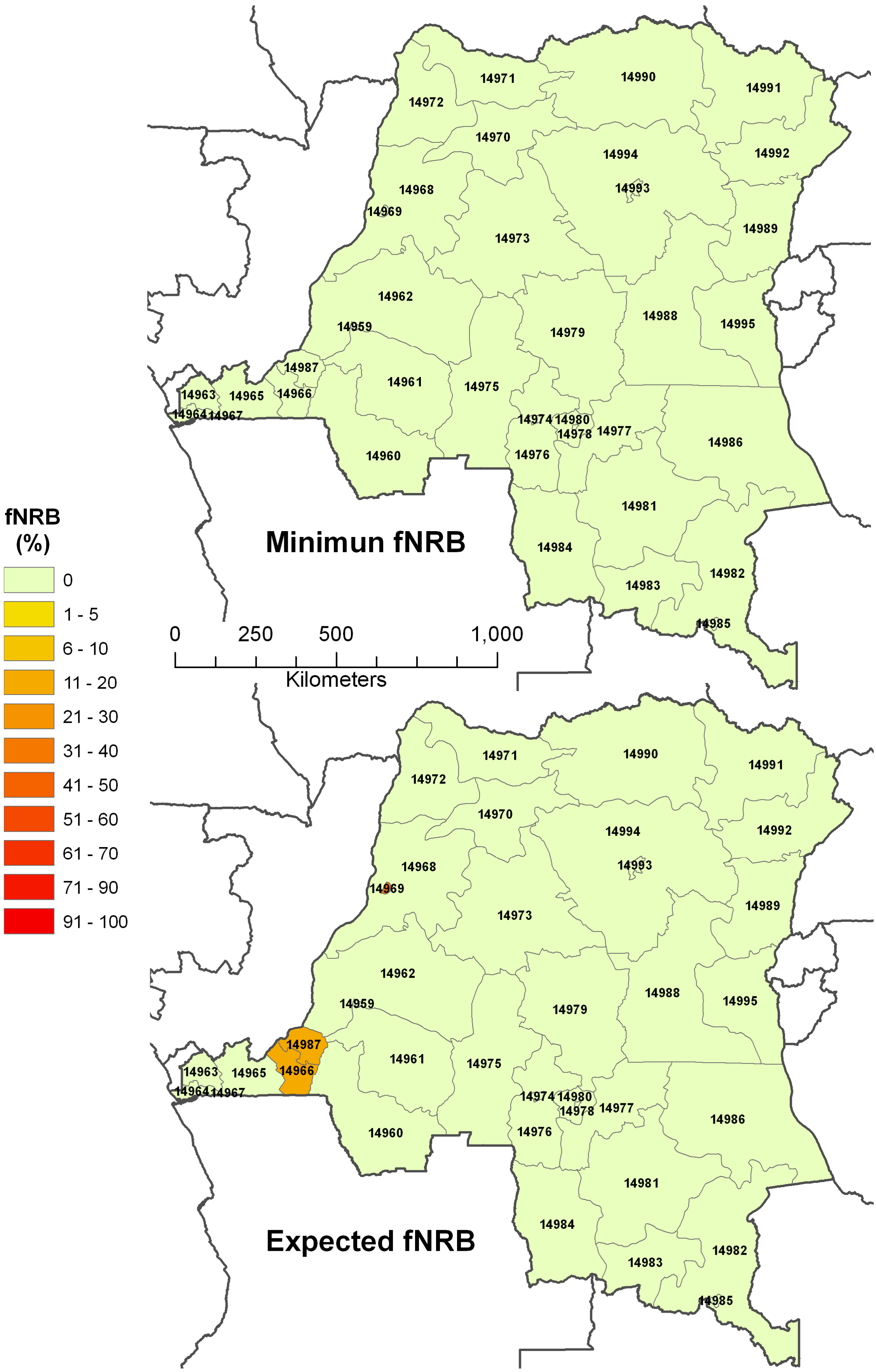


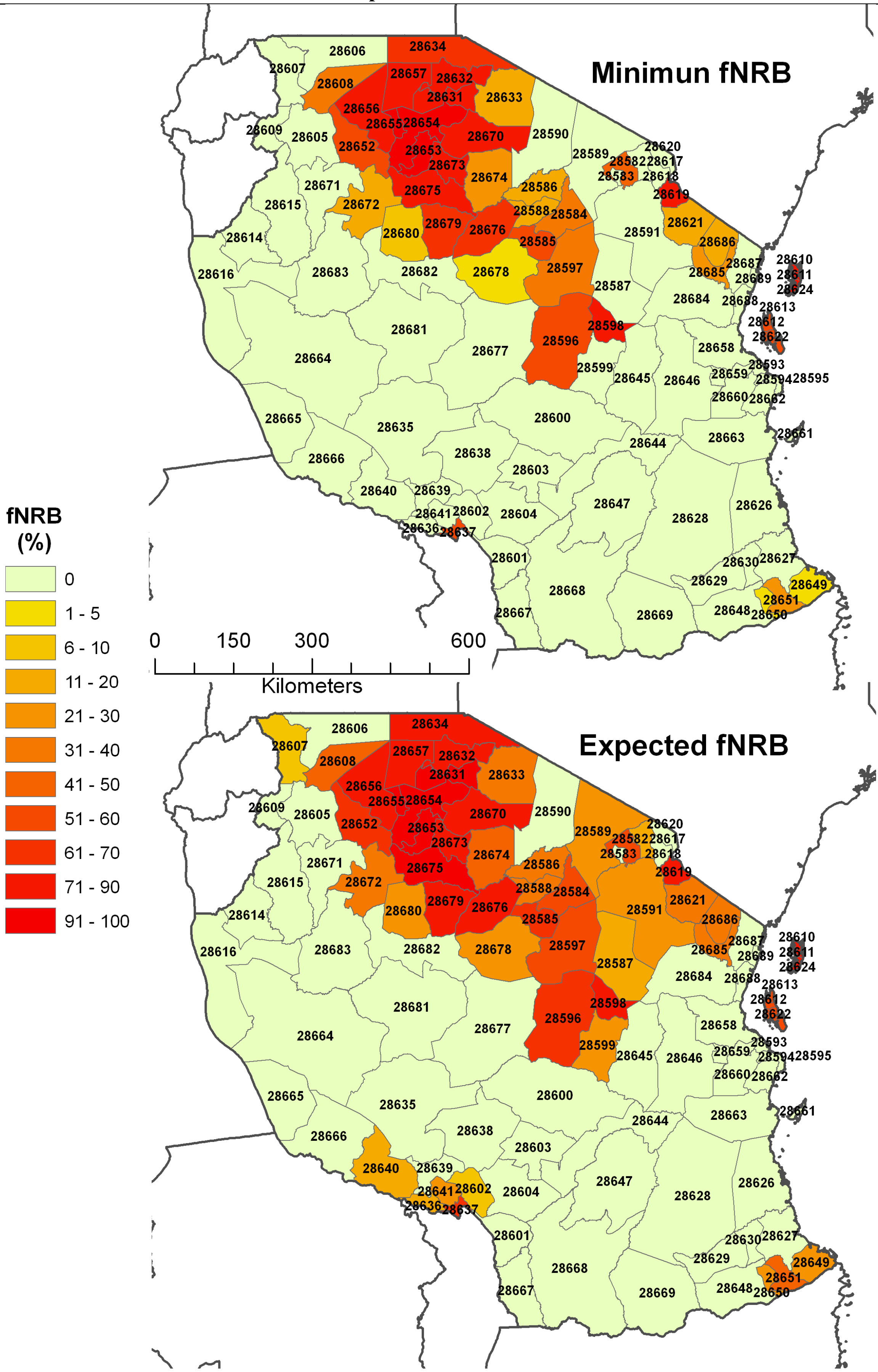
Table A2.10: Tanzania
Reference year: 2000. Mid-range estimates

Country	g06_1	Subnational Unit	Minimum fNRB (mfNRB)	Expected fNRB
Tanzania	28582	Arumeru	**48.8**	**54.6**
Tanzania	28583	Arusha	0.0	0.0
Tanzania	28584	Babati	**34.6**	**50.2**
Tanzania	28585	Hanang	**54.1**	**65.3**
Tanzania	28586	Karatu	**17.1**	**36.6**
Tanzania	28587	Kiteto	0.0	**18.7**
Tanzania	28588	Mbulu	**13.9**	**34.8**
Tanzania	28589	Monduli	0.0	**27.4**
Tanzania	28590	Ngorongoro	0.0	0.0
Tanzania	28591	Simanjiro	0.0	**20.7**
Tanzania	28592	Ilala	0.0	0.0
Tanzania	28593	Kinondoni	0.0	0.0
Tanzania	28594	Temeke	0.0	0.0
Tanzania	28596	Dodoma	**51.7**	**63.8**
Tanzania	28597	Kondoa	**35.6**	**51.5**
Tanzania	28598	Kongwa	**84.7**	**88.4**
Tanzania	28599	Mpwapwa	0.0	**20.3**
Tanzania	28600	Iringa	0.0	0.0
Tanzania	28601	Ludewa	0.0	0.0
Tanzania	28602	Makete	0.0	**5.4**
Tanzania	28603	Mufindi	0.0	0.0
Tanzania	28604	Njombe	0.0	0.0
Tanzania	28605	Biharamulo	0.0	0.0
Tanzania	28606	Bukoba	0.0	0.0
Tanzania	28607	Karagwe	0.0	**5.7**
Tanzania	28608	Muleba	**31.6**	**47.7**
Tanzania	28609	Ngara	0.0	0.0
Tanzania	28610	Micheweni-pemba	**75.5**	**75.5**
Tanzania	28611	Wete-pemba	**75.5**	**75.5**
Tanzania	28612	Zansibar North	**53.2**	**55.7**
Tanzania	28613	Zansibar North-central	**51.4**	**51.4**
Tanzania	28614	Kasulu	0.0	0.0
Tanzania	28615	Kibondo	0.0	0.0
Tanzania	28616	Kigoma	0.0	0.0
Tanzania	28617	Hai	0.0	**11.6**
Tanzania	28618	Moshi	0.0	0.0
Tanzania	28619	Mwanga	**79.1**	**83.3**
Tanzania	28620	Rombo	0.0	0.0
Tanzania	28621	Same	**16.7**	**35.5**
Tanzania	28622	Zansibar Central	**53.1**	**55.0**
Tanzania	28623	Zansibar South	**52.2**	**56.0**
Tanzania	28624	Chakechake	**75.5**	**75.5**
Tanzania	28625	Mkoani	**75.5**	**75.5**
Tanzania	28626	Kilwa	0.0	0.0
Tanzania	28627	Lindi	0.0	0.0
Tanzania	28628	Liwale	0.0	0.0
Tanzania	28629	Nachingwea	0.0	0.0
Tanzania	28630	Ruangwa	0.0	0.0
Tanzania	28631	Bunda	**87.3**	**90.4**
Tanzania	28632	Musoma	**79.5**	**84.4**
Tanzania	28633	Serengeti	**12.4**	**35.3**
Tanzania	28634	Tarime	**69.7**	**75.0**
Tanzania	28635	Chunya	0.0	0.0
Tanzania	28636	Ileje	0.0	**13.0**
Tanzania	28637	Kyela	**58.1**	**68.1**
Tanzania	28638	Mbarali	0.0	0.0

(continued)

Country	g06_1	Subnational Unit	Minimum fNRB (mfNRB)	Expected fNRB
Tanzania	28639	Mbeya	0.0	0.0
Tanzania	28640	Mbozi	0.0	**17.9**
Tanzania	28641	Rungwe	0.0	**21.0**
Tanzania	28643	Zansibar West	**51.4**	**51.4**
Tanzania	28644	Kilombero	0.0	0.0
Tanzania	28645	Kilosa	0.0	0.0
Tanzania	28646	Morogoro	0.0	0.0
Tanzania	28647	Ulanga	0.0	0.0
Tanzania	28648	Masasi	0.0	0.0
Tanzania	28649	Mtwara	**4.6**	**28.4**
Tanzania	28650	Newala	**1.3**	**22.5**
Tanzania	28651	Tandahimba	**25.8**	**44.3**
Tanzania	28652	Geita	**54.5**	**65.7**
Tanzania	28653	Kwimba	**93.8**	**95.2**
Tanzania	28654	Magu	**92.1**	**94.0**
Tanzania	28655	Mwanza	**93.2**	**94.3**
Tanzania	28656	Sengerema	**73.3**	**80.0**
Tanzania	28657	Ukerewe	**84.0**	**86.8**
Tanzania	28658	Bagamoyo	0.0	0.0
Tanzania	28659	Kibaha	0.0	0.0
Tanzania	28660	Kisarawe	0.0	0.0
Tanzania	28661	Mafia	0.0	0.0
Tanzania	28662	Mkulanga	0.0	0.0
Tanzania	28663	Rufiji	0.0	0.0
Tanzania	28664	Mpanda	0.0	0.0
Tanzania	28665	Nkansi	0.0	0.0
Tanzania	28666	Sumbawanga	0.0	0.0
Tanzania	28667	Mbinga	0.0	0.0
Tanzania	28668	Songea	0.0	0.0
Tanzania	28669	Tunduru	0.0	0.0
Tanzania	28670	Bariadi	**74.3**	**80.3**
Tanzania	28671	Bukombe	0.0	0.0
Tanzania	28672	Kahama	**19.2**	**39.6**
Tanzania	28673	Maswa	**80.3**	**85.2**
Tanzania	28674	Meatu	**27.1**	**45.3**
Tanzania	28675	Shinyanga	**90.0**	**92.1**
Tanzania	28676	Iramba	**65.0**	**73.6**
Tanzania	28677	Manyoni	0.0	0.0
Tanzania	28678	Singida	**3.1**	**27.0**
Tanzania	28679	Igunga	**64.3**	**72.7**
Tanzania	28680	Nzega	**5.6**	**27.9**
Tanzania	28681	Sikonge	0.0	0.0
Tanzania	28682	Tabora	0.0	0.0
Tanzania	28683	Urambo	0.0	0.0
Tanzania	28684	Handeni	0.0	0.0
Tanzania	28685	Korogwe	**20.5**	**33.5**
Tanzania	28686	Lushoto	**18.6**	**34.4**
Tanzania	28687	Muheza	0.0	0.0
Tanzania	28688	Pangani	0.0	0.0
Tanzania	28689	Tanga	0.0	0.0
Tanzania		**Total**	**21.0**	**27.3**

Figure A2.11: Tanzania – Minimum and Expected fNRB



Annex 3: Example of WISDOM reference data – the case of Cambodia, Laos and Myanmar

Reference of the WISDOM case study:

FAO. 2007. Wood-energy supply/demand scenarios in the context of poverty mapping. A WISDOM case study in Southeast Asia for the years 2000 and 2015. Prepared by R. Drigo, Environment and Natural Resources Service (SDRN) and Forest Product Service (FOPP), FAO. Environment and Natural Resources Working Paper 27. FAO. ISBN 978-92-5-105710-0. http://www.fao.org/docrep/010/a1106e/a1106e00.htm

Geostatistical data layers used in the original study:

Supply Module

- Land cover maps:
  - GLC 2000;
  - JRC TREES;
  - MODIS tree cover %
- Ecological zoning:
  - FAO FRA GEZ 2000;
  - ICIV Ecofloristic zones
- Protected areas by IUCN-WCMC categories

Volume and biomass reference data for forest and non-forest; Volume expansion factors (VEF); Biomass expansion factors (BEF); Woodfuel fraction (Wf fraction); Mean Annual Increment (MAI); etc.

Stocking and mean annual increment of woody biomass by land cover class and eco zones, including the woody biomass productivity of agricultural and agro-forestry areas (inferred or estimated, depending on available references).

Data on the industrial roundwood production, to be deducted from the total estimated productivity in order to assess the fraction of the potential sustainable productivity available for energy uses.

Estimated fraction of annual woody biomass increment potentially available for energy by land cover class and eco zones.

Demand Module

Population distribution data (30 arc-second resolution)

- Sparse rural population raster maps (< 2000 inh/SqKm)
- Rural settlements maps (> 2000 inh/SqKm)
- Urban Population

Review of woodfuel consumption data (i-WESTAT, RWEDP reports; GFPOS data; etc.) for the estimation of per capita woodfuel consumption in urban, rural settlements and rural sparse contexts by household and non-household users. The data sources and per capita consumption values applied in the original study are reported in the following tables.

References on woodfuel consumption

(Source : FAO 2007)

Table A3.1 Estimates of national consumption of fuelwood and charcoal according to various sources. The highlighted values were selected as current best reference and used for the calculation of per-capita consumption in the Demand Module. Production in '000 m3.

Cambodia

"Best" current references

Fw Country report, which has a slightly lower value than FAOSTAT (based on the regional GFPOS model). WETT 99 figures appear less reliable as they were based on earlier FAOSTAT values.

Ch Country report, which has a much higher value than FAOSTAT (based on the global GFPOS model). WETT 99 figures appear less reliable as they are far lower and based on earlier FAOSTAT values.

	Main source	Source details	1995	1996	1997	1998	1999	2000
Fw	Country Report	GCP/RAS/173/EC Cambodia report by Sok Bung Heng - Final Draft Report of the "Desk Study on national woodfuels and wood energy information analysis –Cambodia"						8 651
	FAOSTAT (2003)	FAO estimate	10 767	10 570	10 575	10 327	10 119	9 931
	GFPOS 1970-2030	Household Fuelwood model: Regional; non-HH Fw model: continental	10 814	10 647	10 586	10 337	10 130	9 931
	WETT99 Best estimate	FAOSTAT (1998) years 1981–1998	6 518	6 680	6 838	6 968		
Ch	Country Report	GCP/RAS/173/EC Cambodia report by Sok Bung Heng - Final Draft Report of the "Desk Study on national woodfuels and wood energy information analysis –Cambodia"						546.8
	FAOSTAT (2003)	FAO estimate	173	176	182	184	196	188
	GFPOS 1970-2030	Charcoal model: Global	173	176	182	184	186	188
	WETT99 Best estimate	Reference not available	13	13	13	13	0	0

Lao PDR

"Best" current references

Fw Country report

Ch Country report

	Main source	Source details	1995	1996	1997	1998	1999	2000
Fw	Country Report	GCP/RAS/173/EC Lao PDR report by Mr Oukham Phiathep, Planning Dept., Ministry of Agriculture and Forestry. Main ref: 1997 STENO (sec.source 149) a	4534	4701	4836	4966	5108	5250
	FAOSTAT (2003)	FAO	5641	5672	5704	5718	5744	5770
	GFPOS 1970–2030	Household Fuelwood model: Regional; non-HH Fw model: continental	5641	5672	5704	5718	5744	5770
	UN Energy Statistics 1995	Reference not available	4404					
	WETT99 Best estimate	FAOSTAT (1998) years 1981-1997	357	366	374	390		
Ch	Country Report	GCP/RAS/173/EC Lao PDR report by Mr Oukham Phiathep, Planning Department, Ministry of Agriculture and Forestry. Main ref: 1997 STENO and other consumption studies (i.e. UNDP/FAO Luang Prabang Watershed Management Proj.). Projections based on population growth.	176	182	187	192	197	202
	FAOSTAT (2003)	FAO estimate	89	92	94	96	99	102
	GFPOS 1970-2030	Charcoal model: Global	89	92	94	96	99	102
	WETT99 Best estimate	FAOSTAT (1998) years 1981–1998	830	855	885	879		

	Myanmar							
	"Best" current references							
Fw	The official Figures of FAOSTAT, which correspond well to the data submitted by Ministry of Energy to IEA							
Ch	In the middle of this extremely wide range of estimates, the values of the GFPOS national model appear more realistic. The model estimates show a reasonable match with the values submitted by the Ministry of Energy to IEA.							
	Main source	Source details	1995	1996	1997	1998	1999	2000
Fw	FAOSTAT (2003)	FAO estimate	17 959	18 260				
	FAOSTAT (2003)	Official Figure			31 448	32 083	34 071	34 332
	GFPOS 1970-2030	Household Fuelwood model: Regional; non-HH Fw model: continental	18 769	18 645	18 549	18 211	18 035	17 863
	IEA (2002)	Data from Ministry of Energy, 1985–2002. Secret. estimates based on 1990 data from World Bank, Programme Sectoral Review of Energy, by J. Sousing *et al.*, Washington D.C., 1991.	34 102	33 557	34 178	34 808	34 695	35 063
	IEA nonOECD_99	Reference not available	30 050		32 779			
	Other National	Myanmar Energy Balances	31 170	30 673	31 165			
	Other National	Paper - Myanmar Internship for National Training on Wood Energy Planning	30 052					
	UN Energy Statistics 1995	Reference not available	19 966					
	WETT99 Best estimate	FAOSTAT (1998) years 1981-1998	19 244	19 594	19 954	18 989		
Ch	FAOSTAT (2003)	Official Figure	276	195			70	58
	GFPOS 1970-2030	Charcoal model: National	785	802	820	827	839	852
	IEA (2002)	Data from Ministry of Energy, 1985–2002. Secret. estimates based on 1990 data from World Bank, Programme Sectoral Review of Energy, by J. Sousing *et al.*, Washington D.C., 1991.	1 261	1 279	1 291	1 297	739	667
	IEA non-OECD_99	Reference not available	4 408	1 969				
	Other National	Myanmar Energy Balances	1 299	1 305	522			
	UN Energy Statistics 1995	Reference not available	1 876					
	WETT99 Best estimate	Reference not available	276	195	210			

Attachment B - Approach based on Mean Annual Increment

Fractional NRB:
Suggested Standardized Baseline Calculation

Developing a standardized baseline for the fractional non-renewability (fNRB) of fuelwood requires estimating the amount of biomass fuelwood in a country or region that is demonstrably renewable (DRB) proportional to total biomass fuelwood consumed (By).

fNRB = NRB/[NRB + DRB]

NRB = By - DRB

The standardized approach recommended here is designed to draw on readily available national and regional forestry data while providing opportunities for input and adjustments from experts such as DNAs or forestry professionals.

CDM Methodologies AMS I.E and II.G currently define demonstrably renewable biomass (DRB) based on the management practices and classification of the land from which biomass originates. In practice, these characteristics are hard to measure, especially at a national or regional level to develop a standardized baseline.

We propose the use of the Mean Annual Increment (MAI) of biomass growth in a country as a quantifiable and conservative representation of the total demonstrably renewable biomass (DRB) resource in the country. The mean annual increment (MAI) is a measure of the amount of growth, on average, in a forest resource during one year, and is calculated by multiplying the growth rate of biomass resources times the total volume of growing stock in the country. Conceptually, any biomass removed (R) from a forest resource beyond that which will regenerate naturally (MAI), can be considered non-renewable (NRB). This yields the equation:

NRB = R – MAI

This is similar to the approach that has been followed under the Gold Standard and in several CDM PDDs. Currently the Gold Standard Methodology recommends using harvest, H, for the equation NRB = H – MAI. The harvest is generally found using FAO data on Industrial Roundwood and Woodfuel Removals. However, applying this approach in many countries yields inconsistent and unreasonable results due to issues with data reliability and availability.

The formula above (NRB = R – MAI) accounts for all biomass removals and all biomass regeneration without focusing specifically on fuelwood demand and supply. As improved cookstove projects reduce demand for fuelwood, it makes sense to focus on the biomass fuelwood consumption (By) of households rather than total biomass removals (R) when calculating NRB. This result in the following equation:

$NRB = B_y - MAI$

Where B_y is the biomass used in the absence of the project activity. However, in this equation, the biomass used by households is compared to the growth (MAI) in the entire country. Clearly, some of the renewable biomass is removed for other purposes such as industrial processes, building, furniture, or other forest products.

In order to have a measure of growth (MAI) that can reasonably be compared to fuelwood consumption, it is necessary to consider only a volume of the MAI that is representative of the proportion of total removals (R) driven by fuelwood consumption (By/R). This portion can be represented by the ratio between fuelwood consumption and total biomass removals:

$$\frac{B_y}{R}$$

This ratio, when applied to the MAI, gives the portion of growth that can be used for fuel, or the renewable portion of fuelwood consumption.

$$DRB = MAI \times \frac{B_y}{R}$$

Removals (R), consist of industrial roundwood, woodfuel, and other removals that may be identified on a country basis. These could include land clearing for agriculture, or other wood product harvest.

This method also presents opportunities for local authorities, such as DNAs, to provide input based on local knowledge. As mentioned previously, information on additional removals in a country can increase the reliability of the value of total removals. Input from forestry experts can improve the growth rate and growing stock used for calculating the Mean Annual Increment. If more accurate estimations of per capita fuelwood use are available, a bottom-up approach can be taken to calculating the B_y value by multiplying per capita consumption by the population using fuelwood.

An additional factor in calculating the DRB that is available for use as fuel is the amount of access that households have to forest resources. This can be influenced by the forestry management and protection practices of the country. If the majority of sustainably managed forest resources are protected and thus inaccessible to wood users, they should not be counted as Demonstrably Renewable Biomass that is available for use as fuel. Therefore, an additional parameter A, or percent of accessible biomass resources, can be applied by to reach a more accurate value for the DRB.

$$DRB = MAI \times \frac{B_y}{R} \times A$$

As established in the methodology, given certain indicators such as increasing fuel prices and increased distance travelled to gather wood, all of the biomass used in the absence of the project activity that cannot be shown as demonstrably renewable is non-renewable.

$NRB = B_y - DRB$

With the new definition of DRB, the equation becomes:

$$NRB = B_y - MAI \times \frac{B_y}{R} \times A$$

The fractional portion of non-renewable biomass can be calculated using the formula given in the methodology:

$$fNRB = \frac{NRB}{NRB + DRB}$$

Inputs **Parameter**	(Example using values for Uganda) **Name**	**Value**	**Unit**	**Suggested Source**	**Note**
GS	Growing Stock	155,300,000	m3	FRA, FAO Tables	Defined by the FAO as: "Volume over bark of all living trees more than X cm in diameter at breast height." (X defined by country)
GR	Growth Rate	2.50%		Consult forestry experts; can use 2.5% default for Africa	Growth of biomass in country
IR	Industrial Roundwood Removals	3,651,000	m3	FRA Country Report	Defined by the FAO as: "The wood removed (volume of roundwood over bark) for production of goods and services other than energy production (woodfuel)."
WR	Woodfuel Removals	42,310,000	m3	FRA Country Report	Defined by the FAO as: "The wood removed for energy production purposes, regardless whether for industrial, commercial or domestic use."
OR	Other Removals	0	m3	Could include land clearing for agriculture	Specific to country
A	% Accessible	100%		If unknown, use 100%	This could reflect the percentage of forests that are protected, and therefore unaccessible for fuelwood use.
B_y	Fuelwood Consumption by Household	29,618,000	m3	Survey Data or UN Database	If using survey data, multiply per person consumption by the population cooking with wood.

Example calculations Uganda

MAI = GR * GS

Growth Rate	2.50%	
Growing Stock	155,300,000	m3
MAI	3,882,500	m3

R = IR + WR + OR

Ind. Roundwood	3,651,000	m3
Woodfuel	42,310,000	m3
Other		
Removals	45,961,000	m3

DRB = MAI * (B_y/R) * A

% A	100%	
MAI (access.)	3,882,500	m3
B_y	29,618,000	m3
R	45,961,000	m3
DRB	2,501,945	m3

NRB = B_y - DRB

B_y	29,618,000	m3
DRB	2,501,945	m3
NRB	27,116,055	m3

fNRB = NRB / (NRB + DRB)

NRB	27,116,055	m3
DRB	2,501,945	m3
fNRB	91.55%	