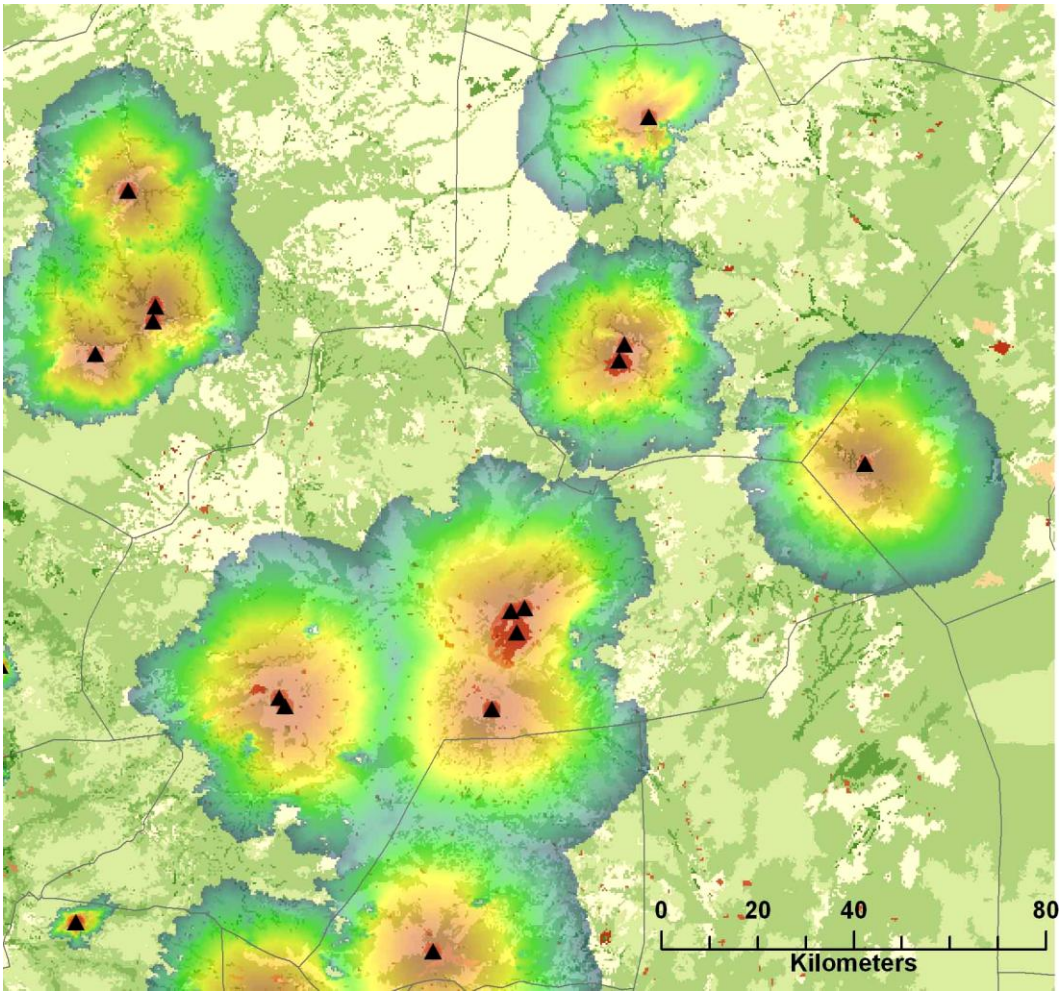
FAO - NRL - DARFUR (OSRO/SUD/823/UEP)

WISDOM Darfur

Land Cover Mapping and Wood Energy Analysis of Darfur's IDP regions

Summary report



Final Report

Land and Water Division (NRL)

December 2010

Acknowledgements

The report is submitted in conclusion of the baby project under the jurisdiction of NRL and in fulfilment of the obligations of NRL in regard to **OSRO/SUD/823/UEP**.

The work is conducted under the technical supervision of the Senior Land and Water Officer (Geospatial) and has been assisted in the process through the close collaboration of the Emergency coordinators office for N. Sudan and the SIFSIA N project.

The land cover analysis has been supervised by Ms Paola Codipietri , consultant to NRL/GLCN programme) with the input of a number of locally based interpreters in FAO HQ's Rome and at the Global Land Cover Topic Centre in Florence. The GIS work has been supervised by Renato Cumani.

The Wisdom analysis and training programme has been conducted by Rudi Drigo consultant to NRL.

This report is written and compiled by Rudi Drigo and Paola Codipietri.

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1. Introduction

1.1 Scope

The scope of this project component was to analyze the wood energy situation in Darfur with special reference to the Internally Displaced Populations (IDP) and to provide the basis for strategic wood energy planning in order to secure subsistence energy supply to vulnerable populations whilst reducing at the same time the unsustainable pressure on the resources of the region.

Main questions to be answered are:

What level of woodfuel demand can be satisfied through sustainable resource management?

Where such management is possible and where not? Which part of the demand should be met by alternative fuels?

What contribution can we expect from improved stoves and from new plantation programmes?

Five sites were preliminarily identified during project formulation, namely Mellit, Kutum, Al Fasher, Al Geneina and Nyala. These are zones with high presence of IDP Camps but they are not the only ones since many of such camps are distributed throughout the central region of Darfur States (see map of IDP camps in Figure 1 and photos in Figure 2), all facing similar subsistence energy shortages. Moreover, woodfuel supply is a common problem also for the population normally residing in the area.

Figure 1: Size and locations of IDP camps in Darfur States. IDP camps (in color the selected sites, in grey all other camps) are shown on the classes of the Global Land Cover 2000 (GLC2000).

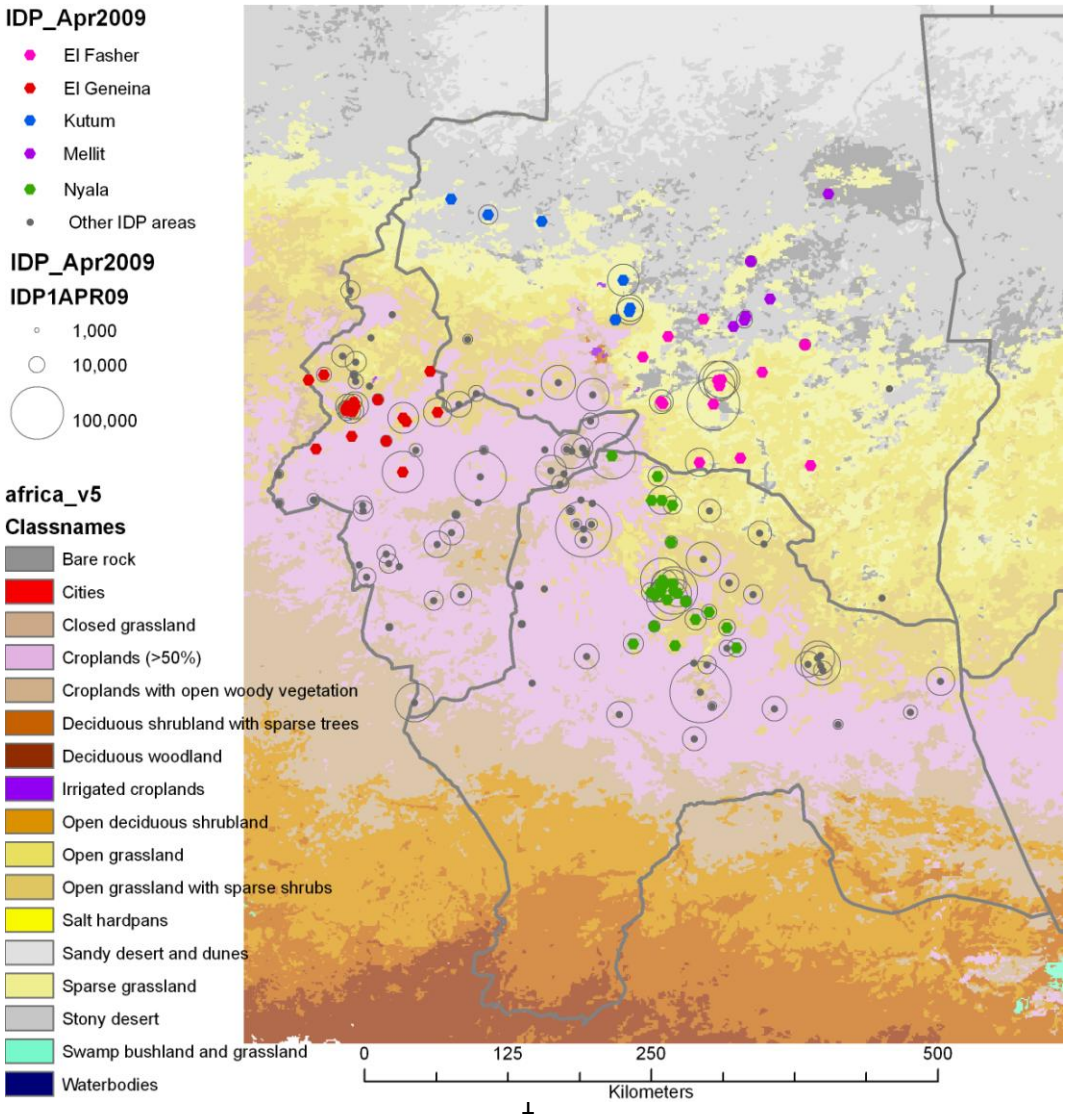


Figure 2: IDP camps seen from the air (source GoogleEarth). Nyala camps, among selected IDP sites and Girayda, an IDP Camp of 134,731 refugees not included among selected sites.

IDP Camp near Nyala. Eldookie GoogleEarth 2010

Refugee camp near Nyala

Refugee camp near Nyala

Portion of the Girayda IDP Camp in Buram, South Darfur, hosting 134,731 persons in April 2010

The demand for fuelwood and charcoal arising from selected IDP camps or from other camps or from resident populations cannot be considered/managed separately because they all compete for the same limited biomass sources. Either the solution for a sustainable supply can be achieved for all demand sectors or for none.

This means that the analysis must be comprehensive, considering all sectors of consumption (IDPs, resident users, commercial and industrial sectors) and all possible sources of woodfuels located in the Darfur area. The Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) methodology was considered the most appropriate one to create a comprehensive knowledge base over Darfur biomass-energy situation, to verify if the sustainable supply and the current consumption within Darfur show a positive balance, what portion of the territory needs to be managed in order to produce the needed woody biomass, as well as other key elements for the formulation of a sound wood energy strategy.

1.2.1 Main feature of the WISDOM method[1]

The methodological approach is based on the following three fundamental characteristics of wood energy

[1] The description of the WISDOM method is largely taken from “Spatial bioenergy analysis : Ten-years experience with the WISDOM model” by Drigo et al. (in press).

systems:

Geographical specificity. The patterns of woodfuel production and consumption, and their associated social, economic and environmental impacts, are site specific (Mahapatra and Mitchell, 1999; FAO/RWEDP, 1997; FAO, 2003d).

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

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

In order to cope with the various dimensions of wood energy, the Wood Energy Programme of the FAO Forest Products Service has developed and implemented the **Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) methodology**, a spatially-explicit planning tool for highlighting and determining woodfuel priority areas or woodfuel hot spots (FAO, 2003). WISDOM is the fruit of collaboration between FAO's Wood Energy Programme and the Institute of Ecology of the National University of Mexico. At national level, the WISDOM approach has been implemented in Mexico (FAO, 2005), Slovenia (FAO, 2004a), Senegal (FAO, 2004b), Castilla y Leon (Spain), Italy, Croatia, Central Africa Republic, Mozambique, Argentina, Rwanda and Peru and it's currently being implemented in Chad. At subregional level, WISDOM was implemented over the eastern and central Africa countries covered by the Africover Programme (FAO, 2005g) and over the countries of South East Asia (FAO, 2007).

WISDOM is meant to create a spatially-explicit knowledge base on supply and demand of woody (and non-woody) biomass for energy and thus to serve as a planning tool for highlighting and determining **priority areas** of intervention and to **focus planning options**. The result of the wall-to-wall supply/demand balance analysis is then used as starting point for the delineation of the necessary supply areas for existing or hypothetical consumption sites.

WISDOM features:

- **Geo-referenced data bases.** A core feature of the approach is the spatial base on which the data is framed. The analysis and presentation of results for all modules is done with the help of a Geographic Information System (GIS).

- **Minimum administrative and spatial units of analysis.** The spatial resolution is defined at the beginning of the study, on the basis of the desired level of detail (national study, regional study) and as constrained by the main parameters or proxy variables that will be used to "spatialize" the information. In most cases the basis for the definition of the administrative level of analysis is provided by the existing demographic data (i.e. census units), which represents the most detailed sub-national structure of a country. The spatial level of analysis (i.e. the size of the pixel in GIS raster data) is usually determined by the mapping detail of the available land use/land cover data.

- **Modular and open structure**. WISDOM consists of modules on demand, supply, integration and woodshed analysis. Each module requires different competencies and data sources and its contents is determined by the data available or, to a limited extent, by the data purposively collected to fill critical data gaps. Once the common spatial base of reporting is defined, each module is developed in total autonomy using existing information and analytical tools and is directed to the collection, harmonization, cross-referencing and geo-referencing of relevant existing information for the area of study.

- **Adaptable framework**. As mentioned previously, the information of relevance to wood energy comes from multiple sources, ranging from census data to local pilot studies or surveys, to projected estimates with unknown sources, and is often fragmented and poorly documented. Proxy variables may be used to "spatialize" discontinuous values. In synthesis, WISDOM tries to make all existing knowledge work for a better understanding of biomass consumption and supply patterns.

- **Comprehensive coverage of woody and non-woody biomass resources and demand from different users**. The analytical framework includes of all sources of biomass potentially available for energy (i.e. fuelwood and charcoal, crop residues, industrial residues, etc.) and all users categories (rural and urban residential; industrial; commercial and public).

The WISDOM methodology may be divided into two sequential stages of analysis[2]:

1 - WISDOM Base. This stage includes the analysis over the entire territory of the study area.

2 - Woodshed[3] analysis. This second stage 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 3.

WISDOM Base

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 minimum administrative *spatial* unit of analysis.
2. Development of the *demand* module.
3. Development of the *supply* module.
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 woodfuel production potentials and physical accessibility parameters.

1.2 Approach

To assure good efficiency of analysis, detailed mapping and data collection was to be done only over the needed area, avoiding the inclusion of superfluous areas as well as the exclusion of important biomass sources necessary to achieve supply/demand balance.

For this, an iterative process was implemented, based on WISDOM methodology, including three distinct phases:

I. Rapid WISDOM appraisal: The demand for woodfuels and the potential sustainable supply is estimated and mapped on the basis of readily available geo-statistical data and "reasonable" assumptions. The results of this preliminary analysis are used for the first cautious delineation of the territory needed for the sustainable woodfuel supply (woodshed). Such woodshed zone represents the target area of the subsequent phases of the project.

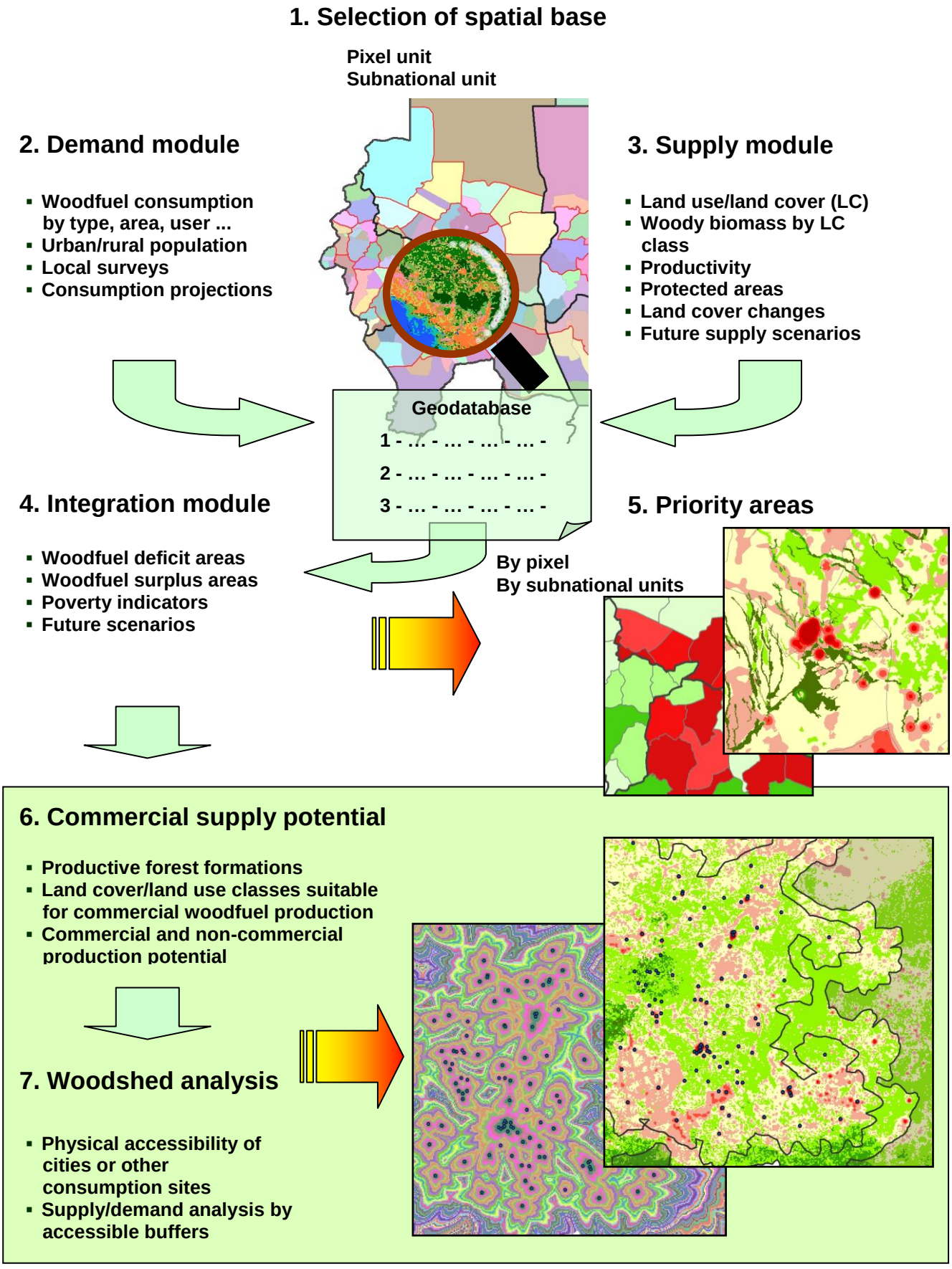
II. Mapping and data collection within the preliminary woodshed zone: Within the woodshed territory defined during the first phase, new land cover mapping is carried out and up-to-date information on consumption patterns and supply potential is collected.

III. Detailed WISDOM Darfur analysis: the new geo-statistical data is used to refine the assessment and mapping supply/demand balance and the actual woodshed is revised accordingly.

[2] In the Darfur case, the WISDOM analysis was carried out twice: once for the rapid appraisal and once for the detailed analysis after land cover mapping and field data collection.

[3] 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 (existing or hypothetical).

Figure 3: WISDOM analytical steps. WISDOM Base (steps 1 to 5) and Woodshed analysis (steps 6, 7)



2 Phase I: Rapid WISDOM Appraisal (RWA)

Since the overarching scope of the wood energy component is to support strategic planning aiming at satisfying subsistence energy needs of IDP camps through sustainable wood energy systems and not to cover selected administrative units, the target territory varies with the quantity and spatial distribution of the demand and the quantity and spatial distribution of the sustainable supply potential.

The scope of the **rapid WISDOM appraisal** (RWA) was to achieve a preliminary definition and delineation of the territory concerned by project action. In practice, this preliminary analysis serves to define the Area of Interest (AoI) of detailed mapping, additional data collection and detailed WISDOM analysis.

In order to guarantee the complete coverage of the territory of interest, the rapid WISDOM appraisal was carried out over the Darfur and Kordofan States.

The administrative subdivision included States and Counties (or Localities).

The selected cell dimension of the raster maps generated, and thus the spatial resolution of analysis, is **10 arc-second**, at this latitude corresponds to approximately 300 m (9.3 ha pixels). The selected resolution and raster features of analysis was based on the global land cover map Globcover (v2.2), which is one of the main references used in the Supply Module.

2.1 RWA Demand module

The analysis of demand was based on the following data sources:

- Demographic data from the 2008 census (by County)
- FAO global map of 2005 population distribution by 30 arc-second cells (FAO 2005 and subsequent update)
- Map of Internally Displaced Population (IDP) camps based on UN official figures from OCHA (source: points map Darfur_Affected_Population_Apr_1_2009_rev090709_wgs84.shp)
- Per capita consumption of woody biomass in Sudan States from the Forest Products Consumption Survey in the Sudan conduced by the Forests National Corporation with FAO assistance (GCP/SUD/047/NET)

The total population considered is that of the 2008 census by County, which includes the normal residents and the IDP.

Concerning the spatial distribution of this population within Counties, one statistical reference, i.e. the census data, and two spatial references were used: the FAO 2005 map and the map of IDP camps with associated number of refugees hosted (see left-side maps in Figure 4) . The resulting population distribution map shown in Figure 4 (right-side map) indicates the likely distribution of the 2008 population within the Counties on the basis of both the overall distribution of the FAO map and the distribution and size of IDP camps.

In the absence of more recent data, the consumption of woody biomass associated to the population was based on the results of the 1995 Forest Products Consumption Survey. The 1995 data refer to pre-war conditions and they are likely to overestimate IDP demand to some extent, but should still be representative of the residential populations. The values applied were conservative, intending that in these cases it is preferable to overestimates the demand rather than underestimate it.

Figure 5 shows the map of woody biomass consumption obtained by associating per capita consumption values (all uses combined) to the population distribution map.

Figure 4: Population distribution map. Top left map: FAO map of 2005 population distribution. Bottom left map: Map of Counties associated to 2008 Census and IDP camps. Right map: Map of the estimated distribution of 2008 population integrating the available spatial and statistical information.

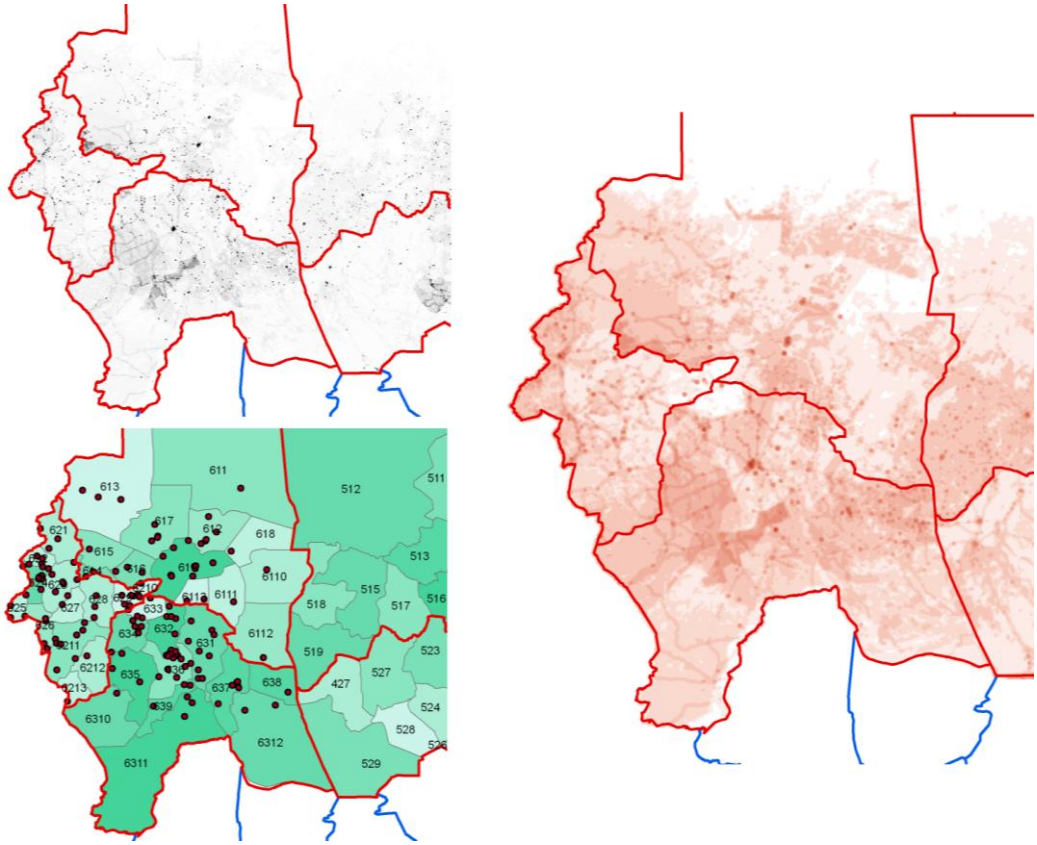
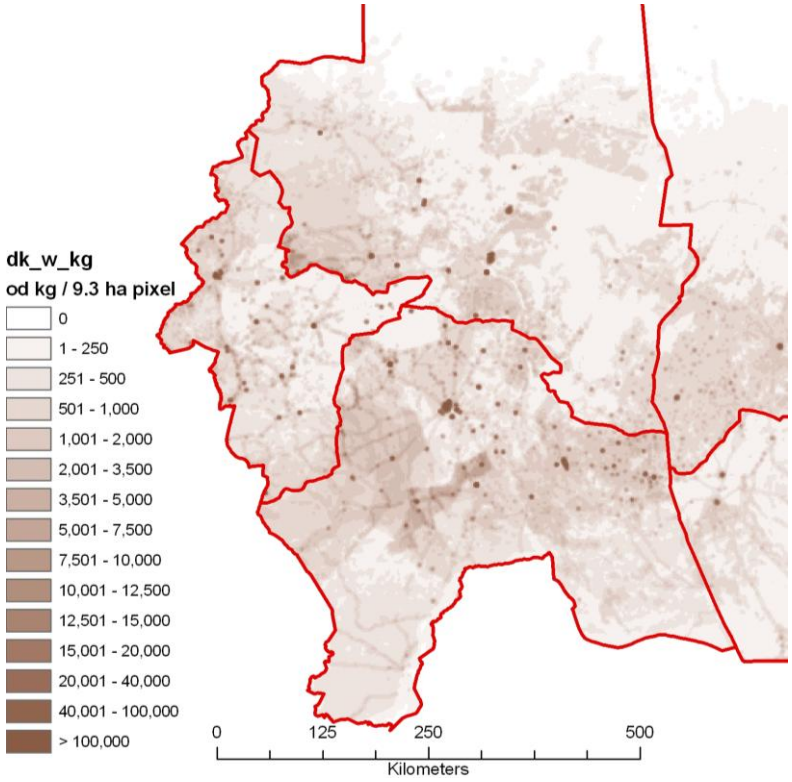


Figure 5: PRELIMINARY Woody biomass consumption map. Map obtained by associating per capita consumption values to the population distribution map



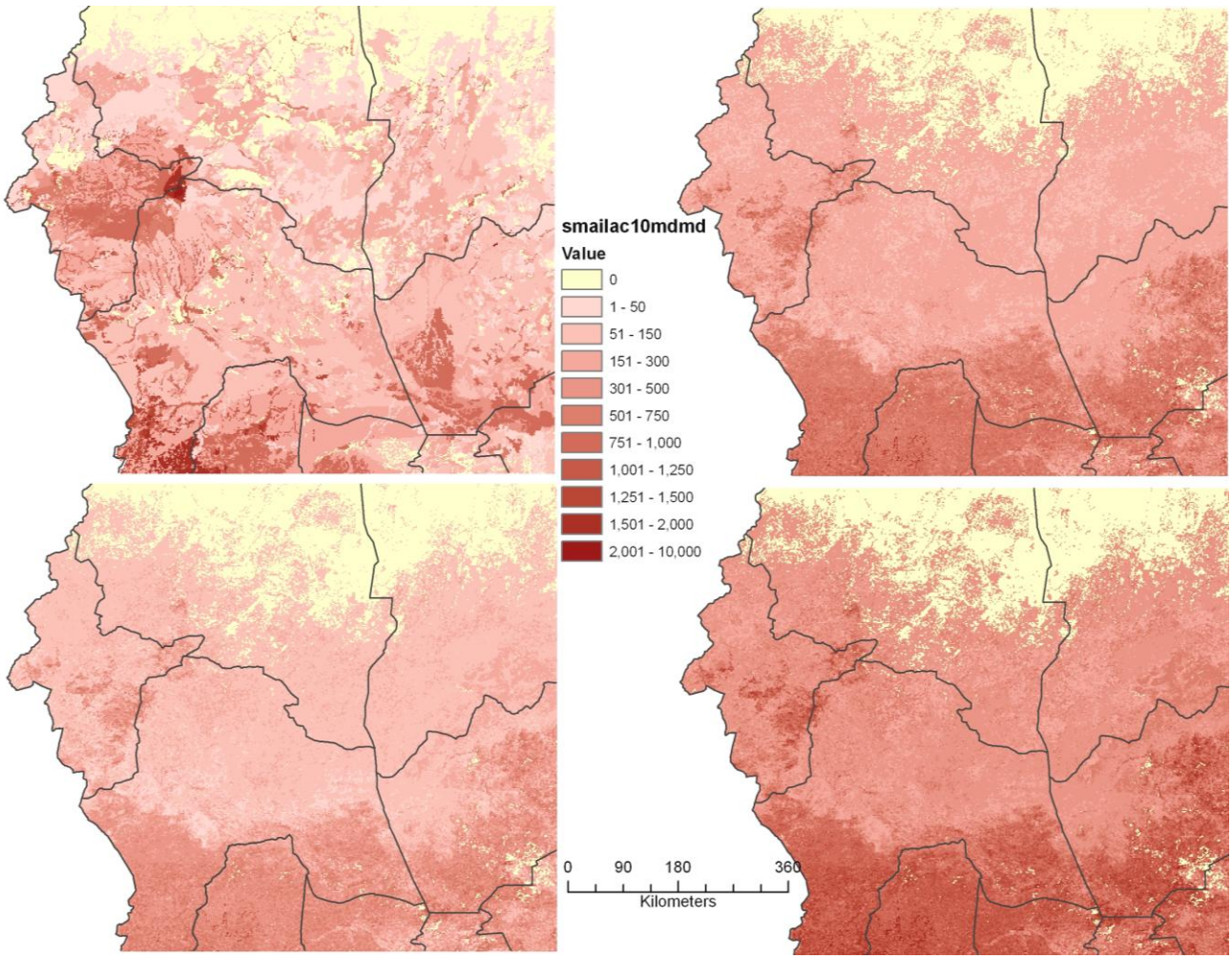
2.2 RWA Supply module

The preliminary estimation of woody biomass stock and sustainable productivity was based on supply module data from two main sources:

- The study "WISDOM East Africa – Spatial woodfuel production and consumption analysis" (Drigo, 2005), which was based on the Land Cover Classification System (LCCS 2) data produced in 2001 for Sudan in the framework of the FAO Programme Africover (Di Gregorio and Jansen, 2000).
- Preliminary results from the on-going study Global WISDOM (Drigo, 2009 unpublished report), which was based on Globcover data, version 2.2.

Figure 6 shows the woody biomass productivity in the region of interest derived from the East Africa study (top left map) as well as the three productivity levels estimated in the Global WISDOM analysis

Figure 6: Woody biomass productivity maps. Top left and top right maps, showing the medium productivity values from the East Africa study and from the Global WISDOM study, respectively. Bottom left and bottom right maps, showing minimum and maximum productivity values, respectively, from the Global WISDOM study. The legend refers to the estimated mean annual increment in 10kg of oven-dry woody biomass by 9.3ha pixels.

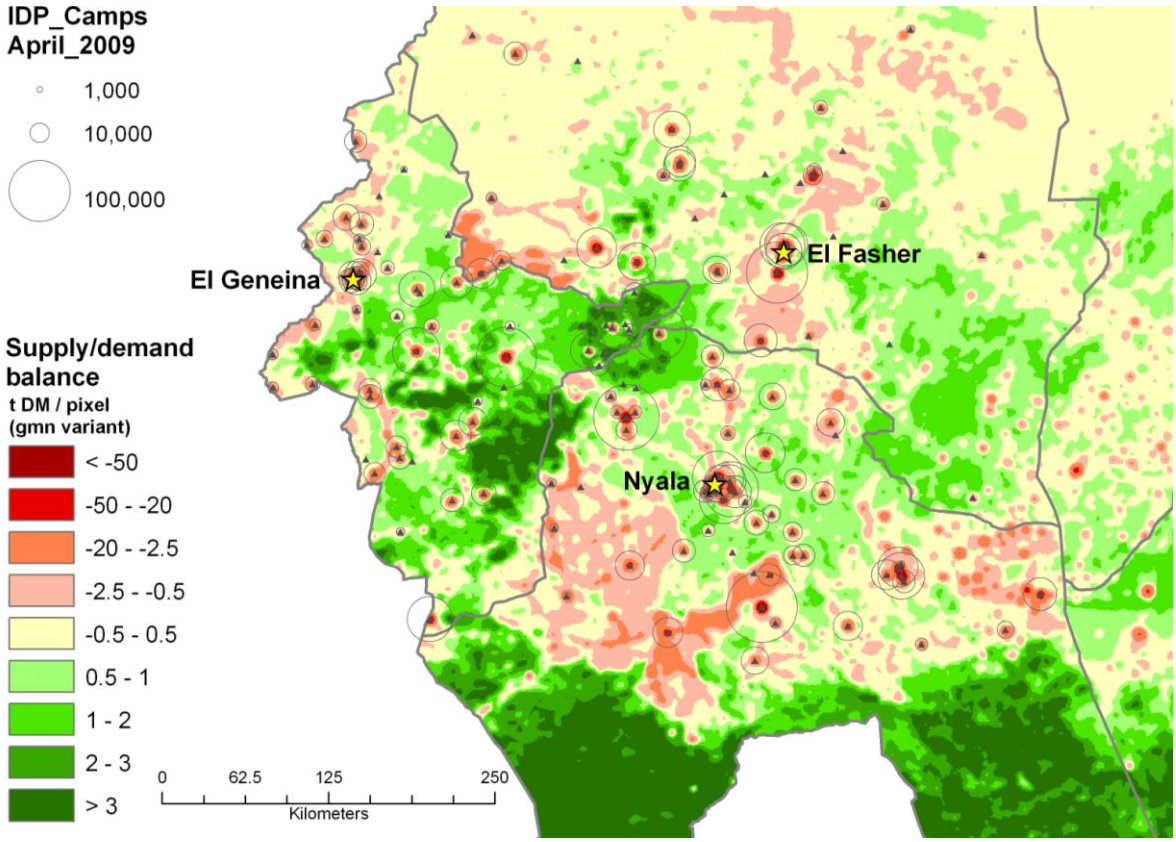


2.3 RWA Integration module

The scope of the Integration Module was to combine the parameters developed in the demand and supply modules by discrete land units (pixels-level and sub-national unit-level) in order to discriminate areas of potential deficit or surplus according to estimated consumption levels and sustainable production potentials.

The result of the RWA integration module is the balance between the preliminarily estimated potential woody biomass productivity and consumption of woody biomass for energy generation and for other uses. Figure 7 shows the balance map based on minimum supply potential, which allowed a "conservative" estimation of balance conditions and subsequent woodshed analysis. In order to better visualize surplus and deficit areas, the map in Figure 7 shows the balance calculated in a local context of 3 km.

Figure 7: RWA Woody biomass supply/demand balance map. The map shows the local neighbourhood balance assuming a 3-km supply/demand context (based on the minimum productivity values from the Global WISDOM study).

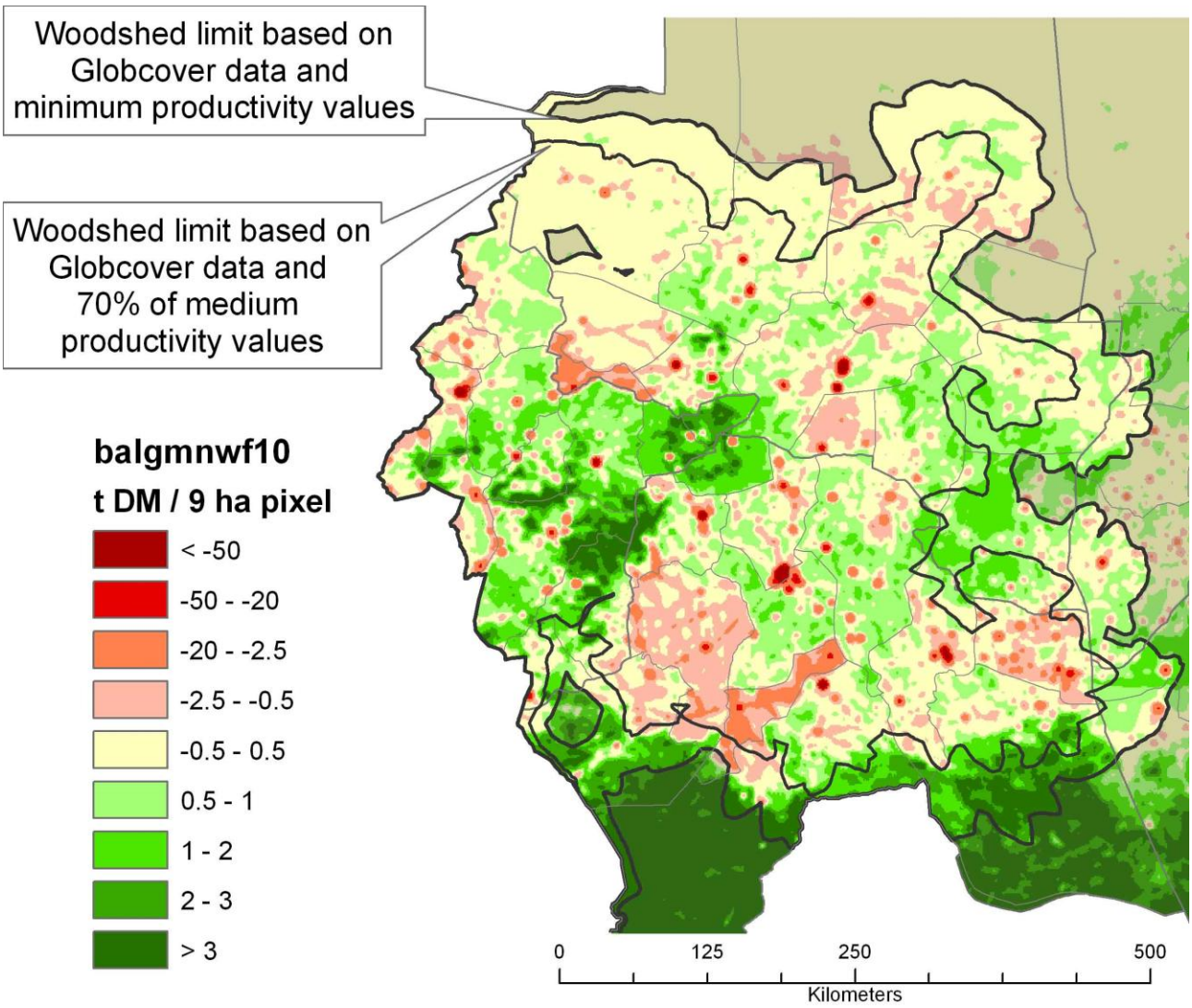


2.4 RWA Woodshed analysis and definition of the Area of Interest (AoI)

The preliminary definition of IDP camps' woodshed, or potential sustainable supply zones, was based on woodfuel production potentials and physical accessibility parameters.

In order to be certain to include a sufficient portion of the territory, the AoI was defined assuming reduced management intensities and lower increment values (Figure 8).

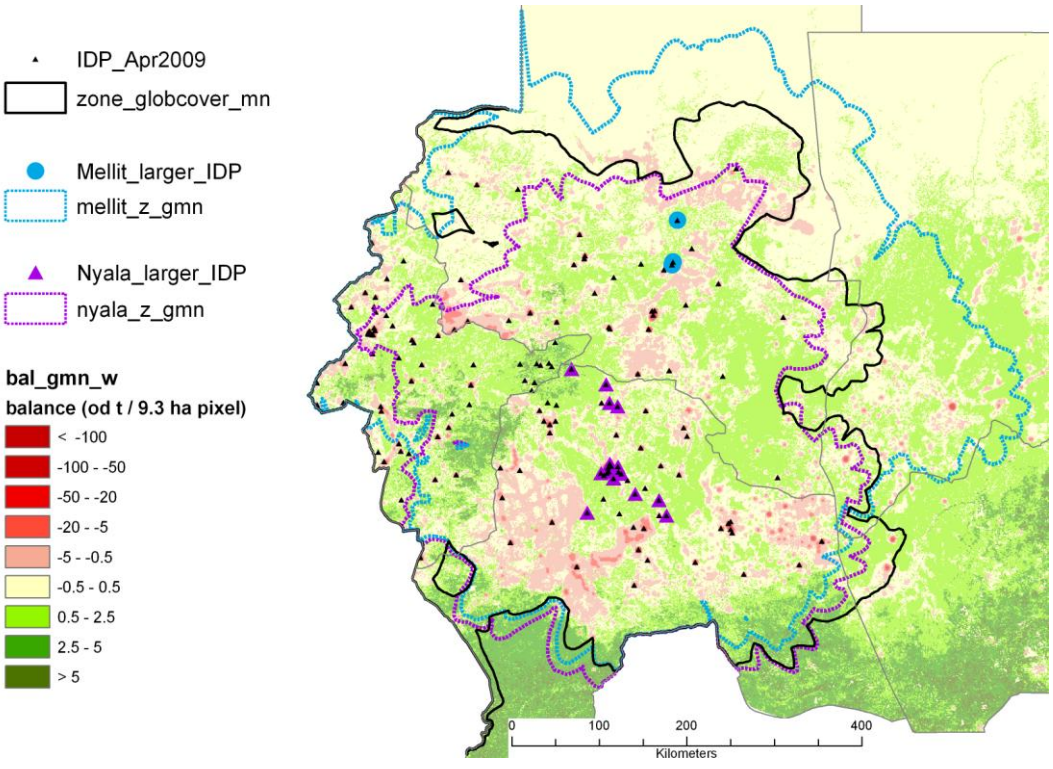
Figure 8: Woodshed zone of IDP camps of Darfur based on the estimated consumption and productivity reference values. The woodshed based on Globcover minimum productivity was used to define the AoI for land cover mapping and detailed WISDOM analysis.



2.5 RWA conclusions and definition of the AoI

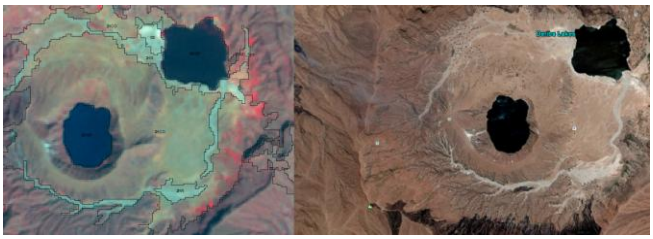
- The different references used to estimate the supply potential produce widely different resulting balance scenarios, which indicates the level of uncertainty inherent in the data (and the necessity to reduce such uncertainty, in future studies, through new land cover mapping and improved biomass data).
- The maximum productivity variant of the Global WISDOM appeared too "optimistic" and was not considered useful for the purpose of the rapid WISDOM appraisal, which produced a "conservative" delineation of the AoI of the project.
- All scenarios related to the preliminary analysis showed an overall positive balance within the Darfur region. This was a positive sign because it indicated the theoretical potential of satisfying subsistence energy needs (and other woody biomass demand sectors) if adequate resource management programmes are put in place[4].
- The extent of the estimated woodshed zone depended on the assumed productivity and consumption while its shape depended on the accessibility of the territory considered. Assuming conservative productivity levels, the sustainable supply zone (i.e. the area to be managed for woody biomass production), with almost 300,000 km^2, covers the entire central Darfur region.
- The extent of the woodshed changes relatively little with the site(s) selected for the analysis. It appears evident that no site is truly independent from the others concerning the supply zone. Figure 9 shows the woodshed based on the Globcover minimum productivity variant of the of the Mellit IDP sites in North Darfur, the one for the Nyala IDP sites in South Darfur as well as the one relative to all IDP sites. The sizes and shapes of these zones are similar, which indicates that there cannot be a resource management solution for one consumption site independently from all other sites.

Figure 9: Results of woodshed analysis starting from different sites. The blue outline refers to the Mellit IDP camps. The purple outline refers to the Nyala IDP camps. The black outline refers to all IDP camps in the Darfur states.



[4] This indication was in good part confirmed in the subsequent Detailed WISDOM analysis, thus confirming the validity of the Rapid Appraisal approach.

3 Phase II: Land Cover Mapping



3.1 Introduction

To support the detailed and up-to-date analysis of woody biomass supply potential, a new land cover map of the AOI was prepared. The land cover mapping constitutes the basis for a reliable assessment of the supply potential and as focal area of a comprehensive wood energy strategy.

The land cover mapping was conducted in parallel to the WISDOM analysis, in synergy with the on-going Land Cover Mapping of Sudan (FAO-GLCN) The mapping follows the FAO-GLCN Land Cover Classification System (LCCS) (DiGregorio and Jansen, 2000) and may be intended as an update and upgrade of the 2001 Africover Map.

3.2 Preparatory Work

3.2.1 AOI Delineation

The priority area was initially defined based on the Administrative boundaries of 5 Districts as defined above: Al Fasher, Kutum, Mellit in Northern Darfur, Al Geneina in Western Darfur, Nyala in Southern Darfur for an approximate total area of 300.000 Km2.

Figure LC1: *Preliminary AOI, 5 Districts*

Figure LC2: *Preliminary AOI and IDP location*

The preliminary AOI is shown in Figure 1, within this area are located 72 IDP's camps.

As shown in Figure 2 this area did not include all the IDP's in the south and included areas in the north that were not interested by the new IDP camps.

The preliminary area was then modified according to the overall data on IDP locations and the minimum sustainable area defined from the Rapid Wisdom analysis.

The IDP location is shown in Figure LC2

The area identified as AOI of the Rapid Wisdom Appraisal analysis is shown in Figure LC3

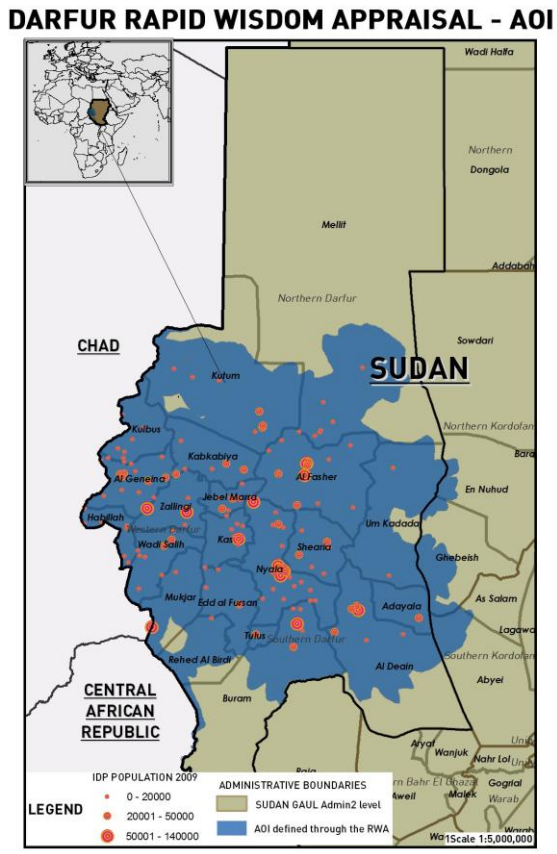


Figure LC3: AOI as defined through the RWA

Figure LC4: output final AOI

According with this additional information a new AOI was defined, and is shown in Figure LC4. The new area includes all the identified IDP and increases the study area up to 340.000 Km2.

The change in the AOI increased the complexity of the land cover mapping extending the area (+ 13%) and including the areas characterized from a higher land cover fragmentation and complexity compared with the northern areas of Northern Darfur.

The irregular shape derived from the RWA area was extended to obtain a more regular boundary as shown in Figure LC4

SATELLITE IMAGE ACQUISITION

A set of Aster images ASTER (Advanced Space borne Thermal Emission and Reflection Radiometer) with 15 m resolution was acquired for the study area.

The area covered by the Aster images is shown in Figure LC5. The majority of image dates ranges from 2005-2010. In few cases images 2000-2005 were acquired to fill minor areas that were not available in the archive for the last five years period.

The object based segmentation and the interpretation were carried out on the Landsat imagery with the support of the Aster images, where available.

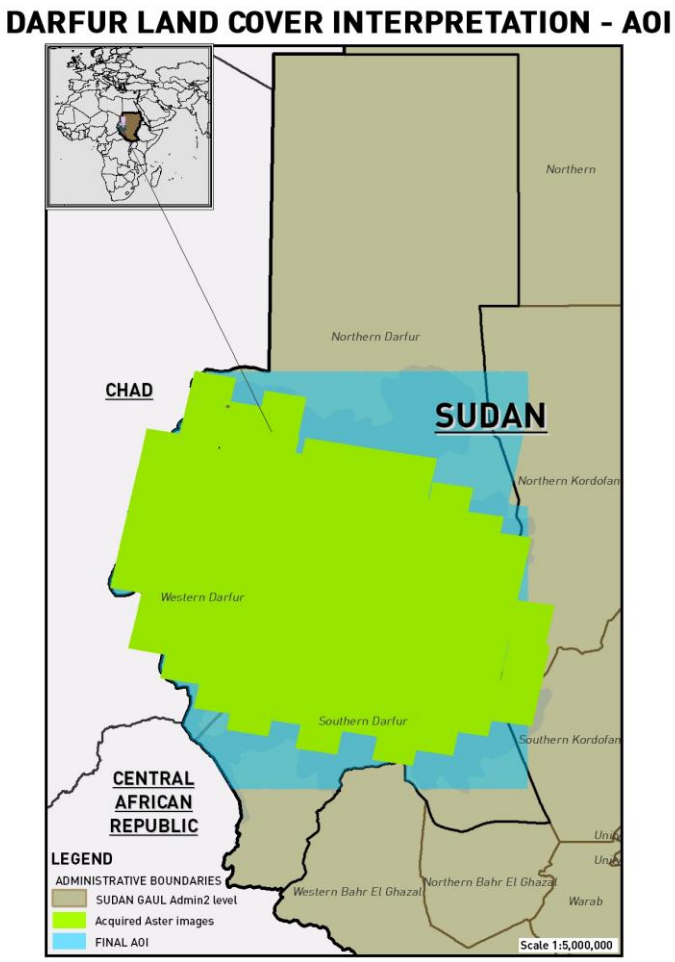


Figure LC5: Acquired Aster images coverage

3.2.3 Classification System and Legend

The land cover legend was built according with the LCCS (FAO Land Cover Classification System) (*http://www.fao.org/docrep/003/x0596e/x0596e00.htm*)

The legend used in the land cover interpretation is shown in Table 1.

According with LCCS Method the classes belongs to 8 major land cover groups

A11 - Cultivated and managed terrestrial areas
A12 – Natural or semi-natural terrestrial vegetation
A23 – Cultivated aquatic or regularly flooded areas
A24 – Natural or semi-natural aquatic vegetation
B15 - Artificial surfaces and associates area(s)
B16 – Bare area(s)
B27 – Artificial water bodies, snow and ice
B28 – Natural water bodies, snow and ice

DARFUR LAND COVER LEGEND

A11 - Cultivated and managed terrestrial areas

Class User Name	Map Code	LCCS Gis Code
Large (>5 Ha) Rainfed Herbaceous Crop(s) + Sparse Trees - Scattered Isolated fields	1HL-is+2TS	10263-11341 + 20053
Medium Rainfed Herbaceous fields - Scattered Isolated	1HM-is	10263-11971
Rainfed Herbaceous Medium (2 - 4 ha) Scattered Isolated Fields with a layer of Natural Sparse (1-15%) Trees	1HM-is+2TS	10263-11971 + 20053
Rainfed Herbaceous Small (<2 ha) Fields - Scattered Isolated fields	1Hs-is	10302
Rainfed Herbaceous Small Fields with Sparse Trees - Scattered Isolated fields	1HS-is+2TS	10302 + 20053
Irrigated Tree Crop (1 add. Herbaceous Crop) - Small Fields	1TR3H57V	10547-12627-W8
Monoculture Of Continuous Large To Medium Sized Field(s) Of Rainfed Shrub Crop(s)	1SHMlm	10565
Monoculture Of Scattered Isolated Large To Medium Sized Field(s) Of Rainfed Shrub Crop(s)	1SHMlm-is	10597
Rainfed Isolated (10-20%) Small (<2ha) Fields of Shrub Crop with Herbaceous Additional Crop	1SHs-is	10632-12626-W8
Large (>5 ha) Tree Plantation	1TPL	11182-11341-W7
Rainfed Shrub Small (<2 ha) Sized Crop with Additional Herbaceous Crop	1SHs	11217-12626
Surface Irrigated Herbaceous Large Crop(s) with Additional Herbaceous Crop Sequential	1HLi	11239-11376
Surface Irrigated Herbaceous Medium Crop(s) with Additional Herbaceous Crop Sequential	1HMi	11239-12006
Irrigated Herbaceous Small Fields (<2 Ha) wirth Additional Herbaceous Crops	1Hsi	11259-12635
Irrigated Tree Crop (No additional Crop) - Small Fields	1TRM	11343
Rainfed Herbaceous Large (> 5 ha) Fields	1HL	11436-11341
Large Rainfed Herbaceous Crop(s) + Sparse Trees	1HL+2TS	11436-11341 + 20053
Rainfed Herbaceous Medium (2-5 ha) Fields	1HM	11436-11971
Rainfed Herbaceous Medium (2-5 ha) Fields + Sparse Trees	1HM+2TS	11436-11971 + 20053
Rainfed Herbaceous Small (<2 Ha) Fields	1HS	11445
Rainfed Herbaceous Small (<2 ha) Fields with a layer of Natural Sparse (1-15%) Trees	1HS+2TS	11445 + 20053
Herbaceous Post Flooding Small (<2 ha) Fields	1Hs-Y	11446

A12 – Natural or semi-natural terrestrial vegetation		
Class User Name	**Map Code**	**LCCS Gis Code**
Closed (> 65%) Shrubs.	2SC	20018
Shrubs Open (70 - 40%)	2Sop	20022-1
Very Open Shrubs (40 - 10 %)	2SVop	20022-3012
Sparse (1-15%) Shrubs.	2SR	20056
Sparse (1-15%) Herbaceous. Scattered herbaceous vegetation	2HR	20059

found in semi arid areas		
Closed (> 65 %) Trees with Closed to Open (>15 %) Shrubs.	2TCS	20278
Trees Open (65-40 %) with Closed to Open (> 15%) Shrubs.	2TO_Sco	20314-1
Trees Very Open (40 - 10 %) with Closed to Open (> 15%) Shrubs	2TVO_Sco	20314-3012
Trees Very Open with Herbaceous Layer Closed to Open and Sparse Shrubs	2TVO_Ss	20868-3012
Closed to Open (100-15%) Herbaceous.	2HCO	21454
Closed to Open (100 - 15 %) Herbaceous with Trees and Shrubs.	2HCOTS	21642

A23 – Cultivated aquatic or regularly flooded areas Class User Name	Map Code	LCCS Gis Code
Large (>5ha) Rice Crops Fields	3HL	3605-1-S0308
Medium (>5ha) Rice Crops	3HM	3605-8-S0308

A24 – Natural or semi-natural aquatic vegetation Class User Name	Map Code	LCCS Gis Code
Closed trees on permanently flooded land	4TCHFF	40040
Trees Open (65-15%) Temporarily (2-4 months) Flooded.	4TOF	40047-R1
Closed herbaceous on temporarily flooded land - fresh water	4HCF	40056-R1
Closed (> 65 %) Herbaceous Temporarily (2-4 months) Flooded with Emergents.	4HCTF	40383-R1
Closed to Open (100-40)% Shrubs With Herbaceous Permanently (> 4 months) Flooded.	4SCHFF	41971-60686
Closed to Open (100-40)% Shrubs With Herbaceous Temporarily (2-4 months) Flooded.	4SCHF	42057-60686
Closed to Open Herbaceous (100-15 %) Permanently Flooded.	4HCFF	42347-R1

B15 - Artificial surfaces and associates area(s) **Class User Name**	**Map Code**	**LCCS Gis Code**
Built Up Area - Oil Fields	5OF	5001-A44Zp1(1)
Urban area – general	5U	5003-9
Urban Areas - Rural Settlements	5UR	5003-9-A44Zp2
Airports	5A	5003-A21

B16 – Bare area(s) **Class User Name**	**Map Code**	**LCCS Gis Code**
Bare rock	6R	6002-1
Bare rock with a thin sand layer	6RL	6002-1(3)[Z8]
Gravels, Stones And/Or Boulders	6G	6002-2
Bare soil	6S	6005

Salt crusts	6SZ	6005(3)[Z2]
Bare soil stony	6ST1	6005-6
Bare soil very stony	6ST2	6005-7
Loose and shifting sand	6L	6006
Dunes (undifferentiated)	6LD4	6009
Shifting Sands / Longitudinal Dune(s)	6LD3	6016

B27 – Artificial water bodies, snow and ice		
Class User Name	**Map Code**	**LCCS Gis Code**
Dams	7WP	7002-5

B28 – Natural water bodies, snow and ice		
Class User Name	**Map Code**	**LCCS Gis Code**
Perennial Rivers	8WFP	8002-1-V1
Perennial (> 9 months) Standing Waterbodies.	8WSP	8002-5-V1
Wadi with scattered vegetation	8WN1V	8003-19-U1
River bank	8WFN2	8003-3
Seasonal river	8WFN1	8003-4
Seasonal waterbodies and lake shore	8WN2	8003-7

3.3 Interpretation Activities

The area to be interpreted approx 340000 Km2 was divided into 45 subsets.

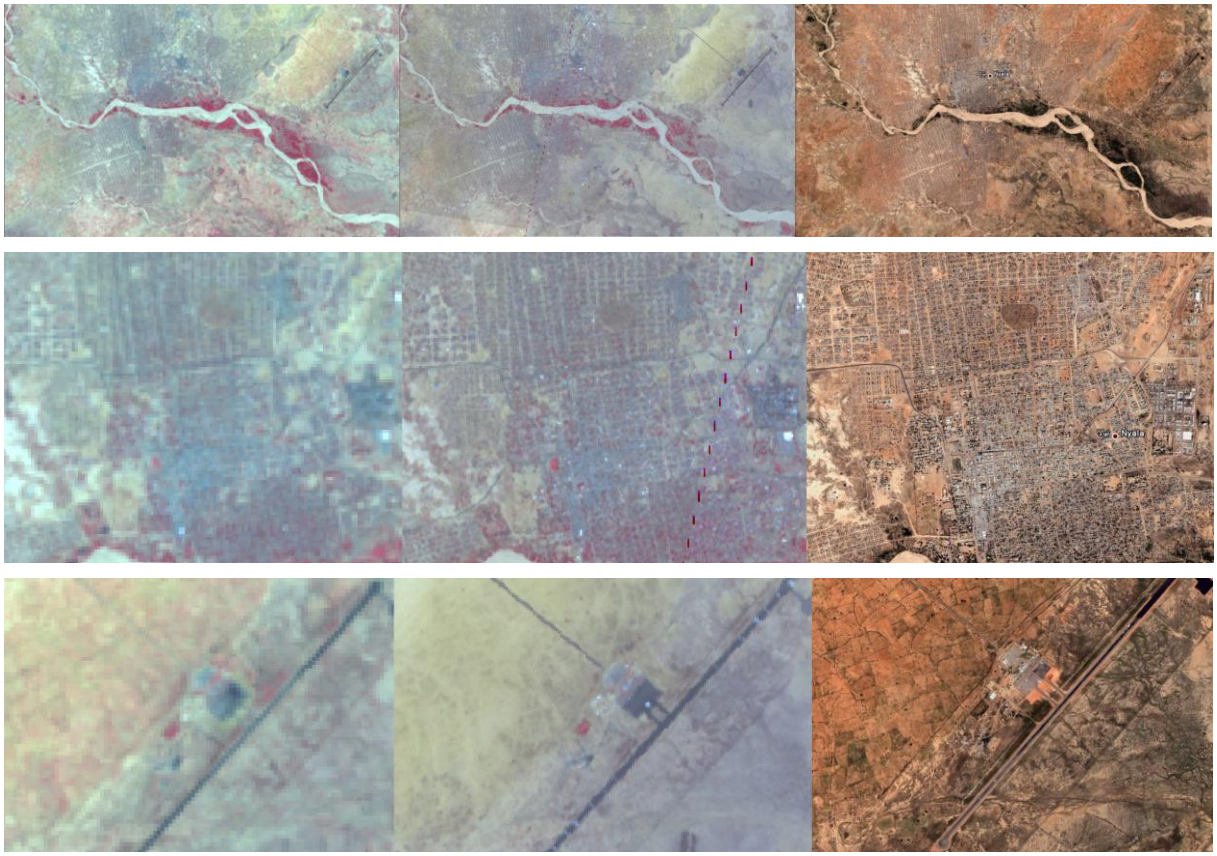
The interpretation was carried out by 6 photointerpreter and each photointerpreter was assigned blocks of contiguous subset for the photointepretation.

The preliminary interpretation was completed in mid November, based on the Landsat images with the support of Aster images and referring to Google Earth high resolution images; where available.

The availability of Google Earth gives useful ancillary information although the high resolution images are not available for the whole area (see a sample of different resolution images in Google in Figure LC5).

Aster image Google images at different resolution Google detail

The use of multiple images can reduce the misinterpretation due to seasonality effects both in the agricultural areas where the visibility of fields can be reduced in the non cropping season and in natural vegetation areas characterized from deciduous species.



Landsat Aster Google Earth

Figure LC5: Different images/resolution available

A review of the preliminary interpretation was carried after the fieldwork campaign to improve both the accuracy and consistency of the interpretation between different interpreters that were involved.

3.4 Field Work Activities

The field work objective was to collect information on the main vegetation parameters (vegetation layers, height, crown cover etc) in representative areas, as well as to clarify doubts on the land cover classification of specific areas. It is an essential component to support the interpretation activities and the map validation.

The methodology proposed for the field work was the standard FAO-Africover methodology.

Field data describes the reality on the ground and were collected to confirm or correct the preliminary photo-interpretation.

The areas where field samples were conducted were usually identified after the preliminary photo-interpretation was completed.

On the map, they were marked by a rectangular sampling quadrat representative of the polygon/land cover type to be checked.

2 main criteria were applied during the selection of the field samples areas:

Criteria related to the photo-interpretation activity

• the most frequent land cover types

• areas in which there were doubts about the correctness of the interpretation

Criteria related to logistic aspects

• accessibility of the area

• clustering of the field samples

For the Darfur AOI, at the end of the preliminary interpretation ca. 200 field work sites were selected within the AOI for the field work campaign. In November 2010 2 teams (1 surveyor 1 driver) were hired to carry out the field survey.

Due to security reasons only a limited area could be surveyed, and within this area only some of the selected points were reached. Other points were recorded within the accessible area for a total number of 40 points (see Annex 1. Surveyors report)

Below are shown some pictures samples from the field survey. The pictures are collected on the 4 cardinal directions N-E-S-W

Survey S13

Survey N06

Survey N16

Survey N19

Survey N22

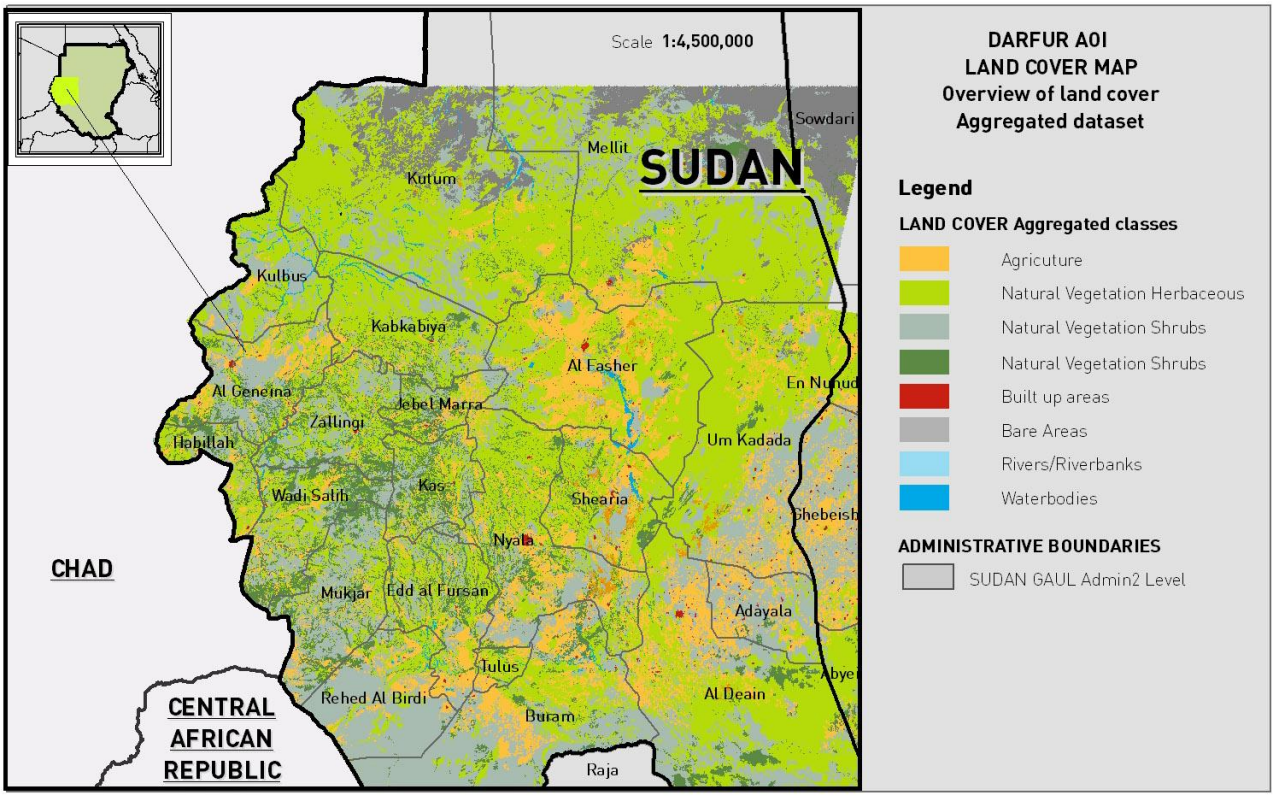
Survey S06

As previously specified, there were security and accessibility limitations in reaching the defined field work areas. To compensate this problem, other points, not previously defined, were sampled to have additional data. The limited accessibility affected the number of land cover types that could be sampled and the representative nature of the sample for the area.

The fieldwork data highlighted an overestimate of natural vegetation cover in some areas that were identified as Shrub vegetation very open instead of sparse. These areas were revised accordingly

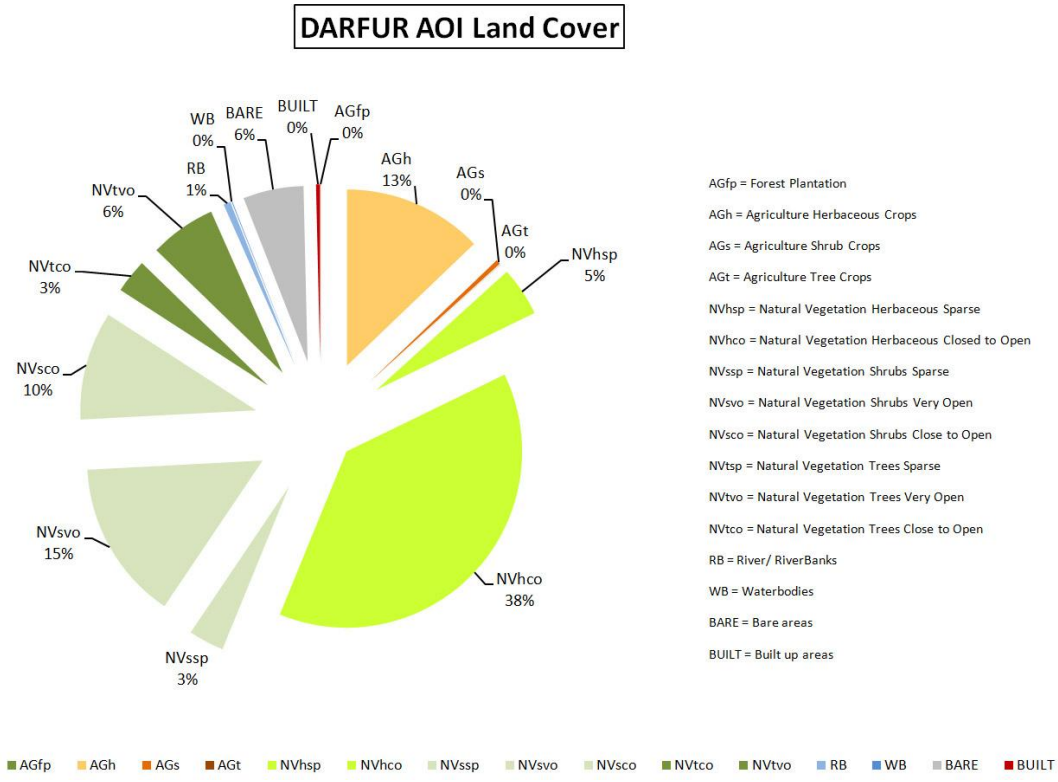
3.5 Results and Conclusions

The map below shows an overview of the final Land cover data. In the overview the land cover classes were aggregated according to 8 major land cover types. For mixed classes units the polygon is attributed to the first class.



The distribution of the Land Cover classes is shown in the graph below. The classes were aggregated according to the land cover type (Natural vegetation or Agriculture and within these groups according with the dominant layer Herbaceous, Shrub or Tree layer, and according to the crown cover density (Closed to Open 100-40%, Very Open 40-10%, Sparse 1-10%)

Natural vegetation covers the majority of the area and, within the natural vegetation class, the herbaceous cover has a widest distribution of all land cover classes.



The area calculation is subject to the following cartography rules and approximations:

The polygons are labelled with a single class code if the main class covers more than 80% of the polygon area. This rate is valid for natural vegetation and does not apply to the agricultural areas where the minimum area covered within the polygon is 10-15% (in this cases the class 'isolated field is applied).

For single class polygons the full area is attributed to the main code.

In mixed class polygons 60% of the area is attributed to the first class and 40% to the second class of the mixed unit.

The new land cover represent an update of the Africover land cover map, and was reached through the interpretation of new imagery and thanks to additional functionality of the new FAO software and tools. However due to the time required for the interpretation of the full AOI (ca 340.000 Km2) and due to the postponed date of the field work campaign, only a limited time could be allocated to the final review of the interpretation after the field work. Furthermore, due to accessibility limitations, the number of samples collected in the field work campaign could not cover all the expected class types and also be considered representative for the area. It is suggested that additional time is allocated to additional quality control to the whole AOI in future studies.

4 Phase III: Detailed WISDOM analysis

In the Detailed WISDOM Analysis, all the assumptions made during the Rapid WISDOM Appraisal were reviewed on the basis of the new land cover data and more detailed local information.

The spatial resolution was increased to 100 m cell size, each map pixel covering one hectare. Concerning administrative data, the level of analysis was increased to Administrative Units (subdivisions of Localities) as far as this was supported by the available data.

4.1 Demand Module

The main objective, and challenge, of the Demand Module was to produce the best possible assessment and mapping of current wood consumption pattern. Primarily, this implied the quantitative estimation of the changes in the consumption of woodfuels in Darfur that intervened since the last comprehensive wood consumption survey, which was conducted in pre-conflict era.

Main references:

(i) The quantitative wood consumption estimates produced by the "Forest Products Consumption Survey in the Sudan" (FNC/FAO GCP/SUD/047/NET, 1996), which provides the latest quantitative estimation referring to pre-conflict conditions.

(ii) Recent reports and studies on Darfur situation, among which the study "Destitution, distortion and deforestation - The impact of conflict on the timber and woodfuel trade in Darfur" (UNEP, November 2008), which provides a qualitative analysis of current conditions.

(iii) Recent review papers on the impact of Fuel Efficient Stoves (FES) programmes, such as ProAct 2008 and USAUD, 2008.

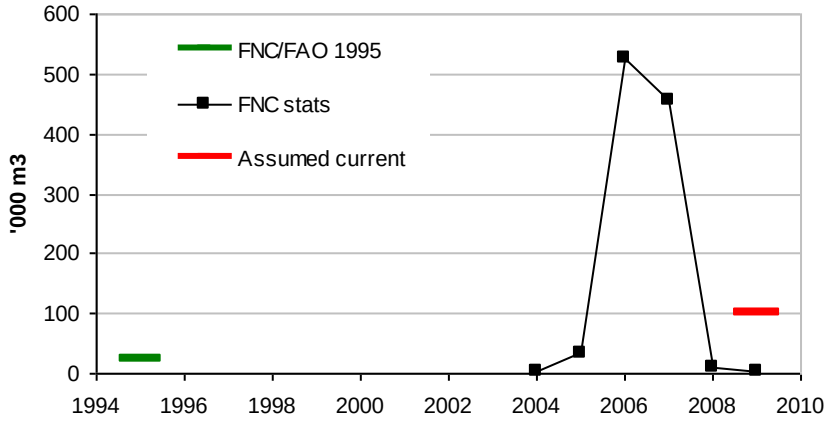
Special attention was given to the fuelwood consumption for brick production, which was indicated in various reports as a particularly aggressive demand sector. The limited available evidence, mainly FNC reporting, shows that bricks production had its climax in 2006-2007 as side-effect of the influx of the international community into Darfur since the conflict begun, as shown in Table 1 . Although it is generally acknowledged that the statistics linked to taxation records produced by FNC capture only part of the true consumption, these seem to confirm the shared impression that the big construction wave has passed and that brick making is now back to "physiologic" levels linked to urbanization processes.

Figure 10 shows in graphic synthesis the prewar consumption estimated by the FNC-FAO survey, the "wave" reported by the taxation records and the annual consumption level assumed for the present study, which is estimated at 106,000 m^3 (4 times higher than pre-war conditions), on account of the increasing urban population and a higher fraction of brick houses.

Table 1: Fuelwood consumed for production of bricks in Darfur, based on FNC reporting.

	North Darfur	**South Darfur**	**West Darfur**	**Tot Darfurf.**	**Source:**
	m^3	m^3	m^3	m^3	
1995				24,080	ref FNC/FAO 1995
2004	0	1,146	590	1,737	ref FNC from UNEP2008
2005	4,666	13,479	14,565	32,710	- do -
2006	376,928	145,712	4,094	526,733	ref: FNC annual reports 2006-2009
2007	332,804	63,000	61,071	456,875	- do -
2008	0	4,450	5,005	9,455	- do -
2009	583	0	4,014	4,598	- do -

Figure 10: Consumption of fuelwood for brick production in Darfur, showing pre-war consumption levels, the climax production due to the influx of the international community and the consumption level assumed for the present study.



The per capita household consumption for cooking in IDP Camps was based on the results produced by CHF International through a systematic informal survey of IDP households in Darfur to assess their FES program (USAID, 2007). In absence of new quantitative estimates for all other uses and sectors of consumption, these were estimated, tentatively, by applying "adjustment" factors to the FNC-FAO 1995 per capita consumption values.

Table 2 shows the assumptions made and factors applied in the attempt of updating the per capita consumption rates with respect to the values estimated by the 1995 FNC-FAO survey. The table shows also the potential reduction resulting from intensive FES programs in rural and urban areas.

Table 3 presents the per capita consumption values adopted for both BAU and FES scenarios while Table 4 presents the breakdown of the BAU consumption by sector of use and by rural, urban and IDP Camp contexts.

Table 2: Assumptions made in defining current per capita consumption rates

ASSUMPTIONS - BAU variant

Factors applied to FNC95 per capita consumption

Rural		Urban		IDP Camps		
no change	**1**	10% Lower HH cons	**0.9**	cooking	**0.451**	m3 (ref USAID 2007)
		Brick and lime curing	**2**	construction	**0.5**	of urban consumption
		Bakeries	**1.5**	maintenance	**0.3**	of urban consumption
		Vegetable oil	**0**	furniture	**0.3**	of urban consumption
				Other sectors	**0.2**	of urban consumption

ASSUMPTIONS - FES variant

Assuming the impact of a strong Fuel Efficient Stove programme in urban and urban areas

Factors applied to household and Khalwas woodfuel consumption of BAU variant due to intensive FES programs in urban& rural areas

Rural	Urban	IDP Camps
0.7	**0.7**	**1**

So far, FES projects have been restricted to camps in government-controlled areas and, to date, there has been extremely limited coverage of rural and urban areas (ProAct. 2008).

Table 3: Applied per capita consumption values in the "business as usual" (BAU) and "fuel efficient stove" (FES) scenarios, and reference FNC 1995 values.

	FNC95 values			Applied values - BAU variant			Applied values - FES variant		
	General average	Rural	Urban	Rural	Urban	IDP Camps	Rural	Urban	IDP Camps
	Percapita consumption (m^3)								
	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3
North D.	0.89	0.88	0.93	0.88	0.94	0.53	0.65	0.80	0.53
West D.	0.81	0.77	1.24	0.77	1.14	0.55	0.57	0.97	0.55
South D:	0.86	0.82	1.08	0.82	1.01	0.55	0.62	0.86	0.55
Tot Darfur	0.85	0.81	1.07	0.81	1.02	0.55	0.61	0.87	0.54
	Percapita consumption (air-dry kg)								
	ad kg	ad kg	ad kg	ad kg	ad kg	ad kg	ad kg	ad kg	ad kg
North D.	638	631	669	631	677	385	471	577	383
West D.	585	552	890	552	823	397	413	697	395
South D:	623	591	777	591	725	399	446	619	396
Tot Darfur	614	587	769	587	732	394	440	623	392
	Percapita consumption (oven-dry kg)								
	od kg	od kg	od kg	od kg	od kg	od kg	od kg	od kg	od kg
North D.	522	516	547	516	554	315	386	472	313
West D.	478	451	728	451	673	324	338	570	323
South D:	509	484	636	484	593	326	365	506	324
Tot Darfur	502	480	629	480	599	322	360	510	321

Table 4: Sector-wise consumption in rural, urban and IDP camps contexts according to BAU scenario.

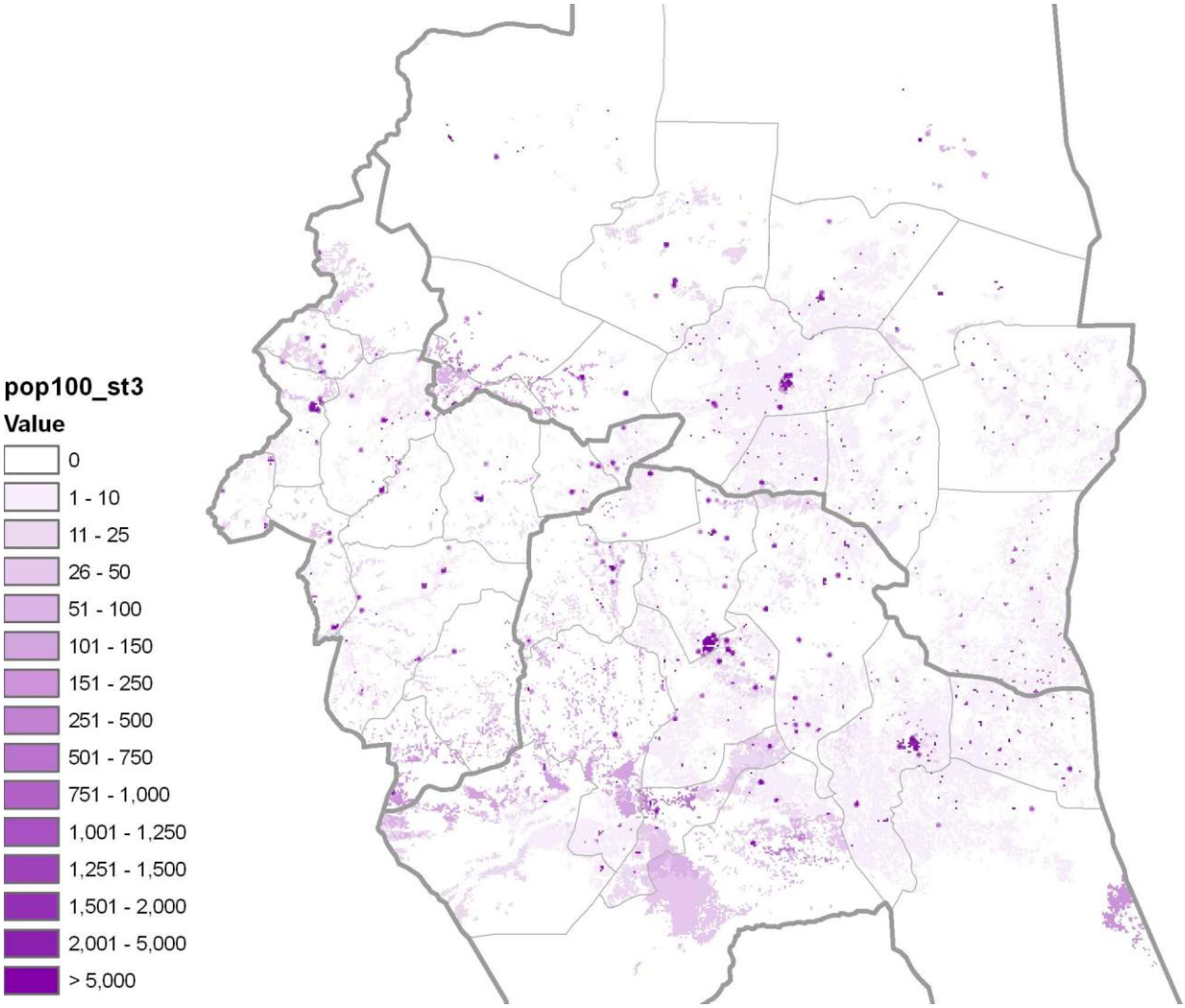
	Rural	Urban	IDP	Rural	Urban	IDP	Total
		%			'000 m^3		
Household	**98.2**	**77.0**	**91.5**	**3,616**	**868**	**978**	**5,462**
cooking	81.4	73.4	82.4	2,998	827	880	4,706
other HH uses	16.8	3.6	9.1	618	41	97	756
Other sectors	**1.8**	**23.0**	**8.5**	**66**	**259**	**91**	**416**
Industrial and commercial		13.0	4.8		147	52	199
brickmaking only		*6.9*	*2.6*		*78*	*28*	*106*
Public (Khalwas mainly)	1.8	9.9	3.7	66	112	39	217
	100	**100**	**100**	**3,682**	**1,127**	**1,069**	**5,878**

Population map

The mapping of Darfur's population distribution was carried out at a higher spatial resolution than for the RWA. Census data at the level of Administrative Unit, rather than Locality/County, was used as statistical reference and several maps features were used as spatial proxy, rather then the FAO 30 arc-second map of population distribution.

The new population distribution map was created integrating demographic statistics providing urban, rural and nomadic population by Administrative Units, administrative maps, the classes of the new land cover map defining urban areas and areas of intensive human activities (as probably populated areas). In view of the high relevance of the geographic distribution and consistency of IDP camps for the present analysis, the available map of IDP camps locations and associated statistics were integrated in the population mapping procedure, in spite of the poor consistency with the demographic data.

Figure 11: Population distribution map (reference years: 2008/2009). Values indicate persons*$(km^2)^{-1}$



Given the limited consistency among the datasets (i.e. the demographic data breakdown is not consistent with the administrative map; inconsistencies between IDP statistics and demographic data; etc.) the population distribution map resulting from this process is not highly accurate. It should rather be considered as a reasonable approximation of 2008/2009 situation.

4.2 Supply Module

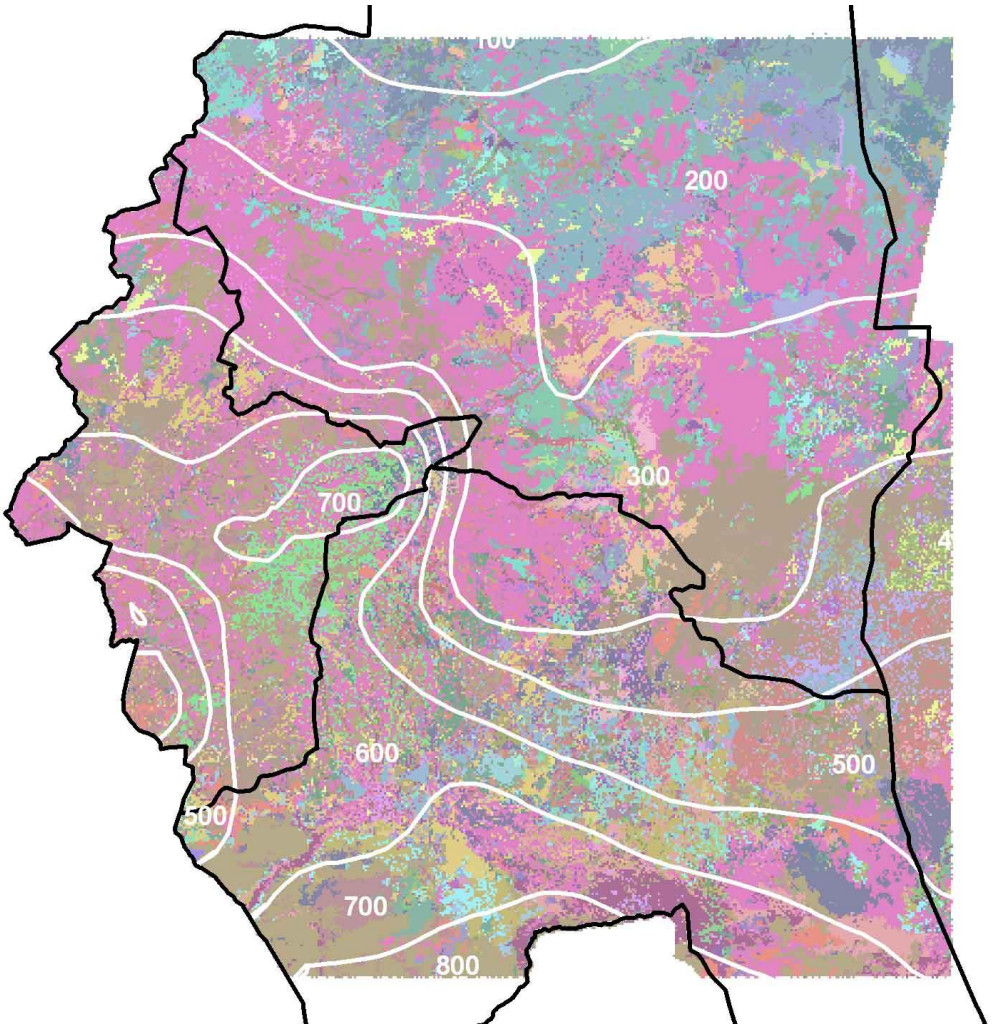
4.2.1 Land Cover and rainfall

A new land cover map of the AoI is the first information layer indispensable for the detailed and up-to-date analysis of woody biomass supply potential.

The land cover mapping constitutes the basis for a reliable assessment of the supply potential and as focal area of a comprehensive wood energy strategy.

The land cover mapping was conducted in parallel to the WISDOM analysis, in synergy with the on-going Land Cover Mapping of Sudan (FAO-GLCN) and with the technical assistance of Paola Codipietro. The mapping follows the FAO-GLCN Land Cover Classification System (LCCS) (DiGregorio and - Jansen, 2000) and may be intended as an update and upgrade of the 2001 Africover Map.

Figure 11: New Land cover map covering the AoI and rainfall zones. The land cover map has 503 unique land cover class combinations (here shown with random colours)

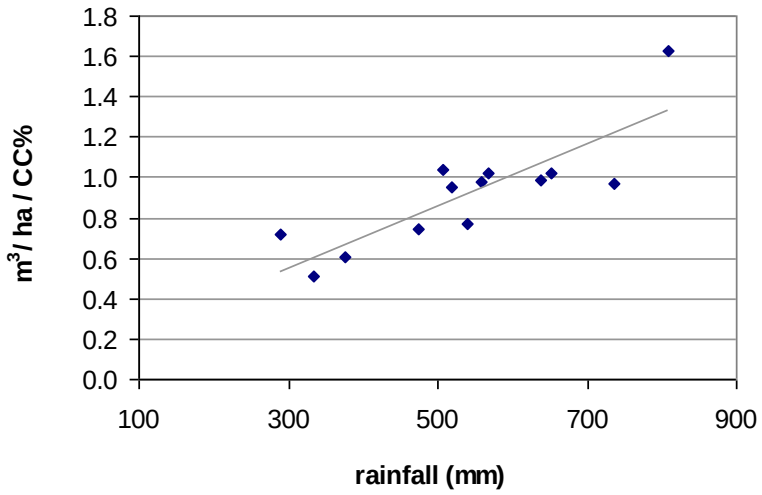


4.2.2 Stock and potential sustainable productivity

In the absence of recent data, the main supporting elements in the estimation of woody biomass stock have been the 1995 National Forest Inventory (NFI) carried out by FNC with FAO support.

The results of the NFI produced estimates of average wood volume of tree formations by geographic locations (map sheets) and by crown cover classes. Combining the geographic areas with rainfall classes permitted the estimation of the increase of tree volume corresponding to the increase of one percent in crown cover in the various ecological zones.

Figure _: Tree volume associated to crown cover percent by rainfall class from NFI results.



Unfortunately, the different approach applied in the NFI and in the LCCS mapping for the estimation of crown cover percent prevented the direct application of the NFI-based function to LCCS data: NFI crown cover was derived from the visual assessment of tree crown diameters from the ground, while the new LCCS implied the estimation of crown cover range values from satellite data.

Thus, once the relative relation between volume, crown cover and rainfall was established, the multiplier value was determined according to the relation between the volume estimated on the basis of the new land cover map and the volume measured in the NFI sample plots for the “unchanged” forest formations. The selected multiplier being the one that gave the best fit in the estimation of woody biomass stock between the two sources.

An important collateral effect of this procedure has been the collection of useful elements for the revision of the crown cover categories of the land cover map and the release of a beta-version of the map.

Productivity

As usual for most African countries, the sustainable productivity of natural formations is a far less known parameter than stock due to the absence of permanent sample plots, which are the only reliable sources of data for the estimation of the Mean Annual Increment.

The 1995 FNC-FAO inventory did not assess the productivity, or MAI, of tree and shrub formations. The only indication of productivity provided in the 1995 inventory report was a quantification of the allowable cut, estimated as 7 % of the stock.

In absence of local data, the estimation of the mean annual increment of natural woody formations was based on the equations relating stock and MAI (as % of stock) that were developed for the Supply Module of Global WISDOM analysis carried out by NRL and FO (Drigo, 2009 unpublished). These equations, which were based on world-wide field observations reporting age of the stand along with biomass (or volume) data,

provide tentative estimations of minimum, medium and maximum MAI values. In addition, an additional equation was based on the reference values indicated in the IPCC Guidelines. According to the medium variant equation, the average MAI of the “forested” formations (stock above 2 od tons per hectares) is 6.9% of stock, raising to 8.3% for stock above 1 od tons and to 8.9% when all formations are included. These values seem to be in line with the value of allowable cut indicated by the NFI.

4.2.3 Accessibility

4.2.3.1 Legal accessibility

According to the 2009 edition of the WCMC-IUCN database of protected areas, there are no internationally known protected areas in Darfur. The presence of protected areas, as well as other restricted-access areas must be verified from national sources.

Statutory functions are also important in this respect and for this purpose it’s necessary to delineate the geographic extent and management objectives of the gazetted Reserved Forests. The list of Reserved Forests in Darfur States as well as in neighbouring Southern Kordofan State are listed in Annex 5. No digital maps are yet available of the Gazetted Forests and consequently these are not included in the analysis. In view of future forest management planning it is strongly recommended to digitize Reserved Forest as soon as possible.

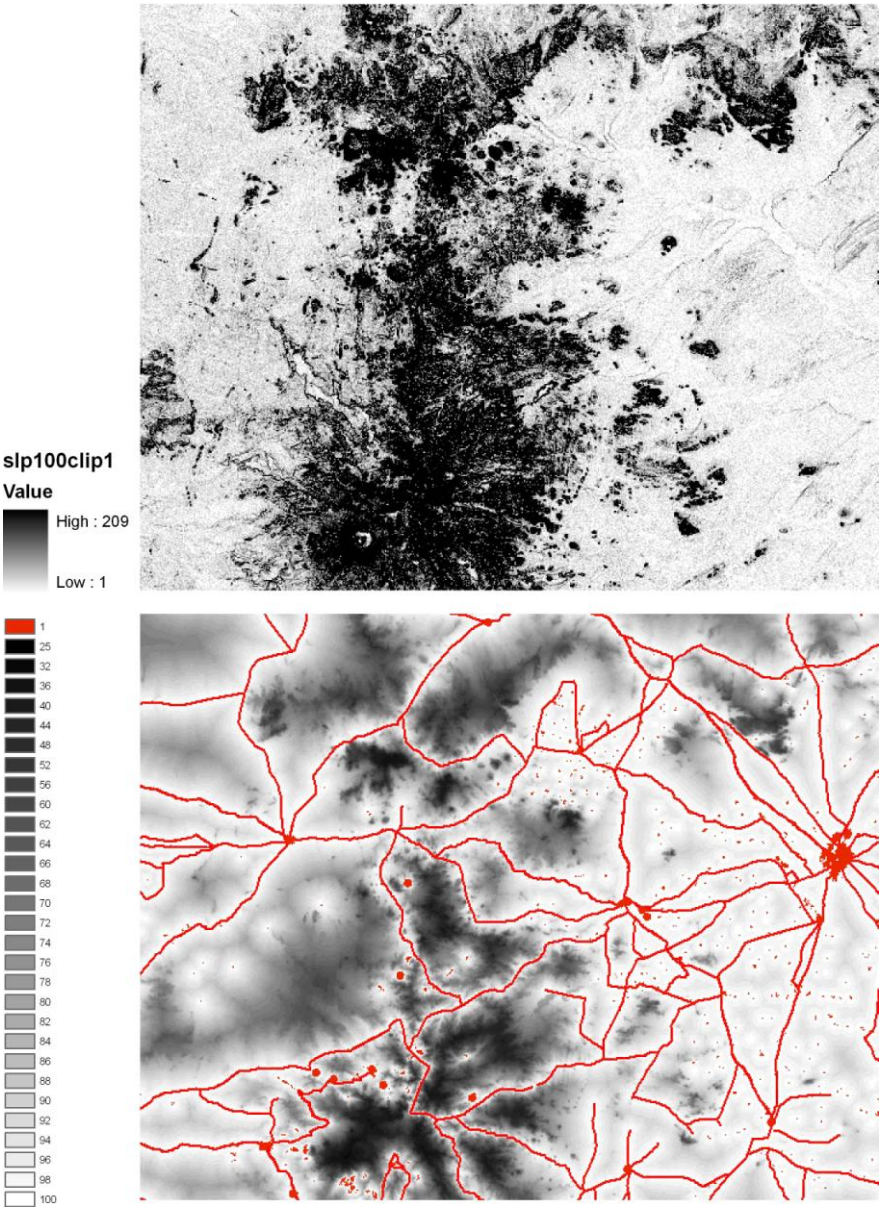
4.2.3.2 Physical accessibility

The analysis of the physical accessibility of woody biomass resources is based on the map of roads and other communication means and on the digital terrain model from which the map of slopes is derived. The accessibility of each cell of the raster map is calculated applying a cost-distance analysis.

This analysis will be based on the following data layers (see Figure 13) :

- Map of road network provided by OCHA Sudan: ;
- The digital terrain model (90 m resolution) transformed into a slope map
- Map of settlements and populated places.

Figure 12: Physical accessibility map. Top: Slope map derived from the 90m Digital Terrain Model. Bottom: Accessibility map with accessible percent values, showing also road network , settlements and IDP Camps (red features). The figure shows a portion of central Darfur.



4.2.3.3 Economic viability of woodfuel production

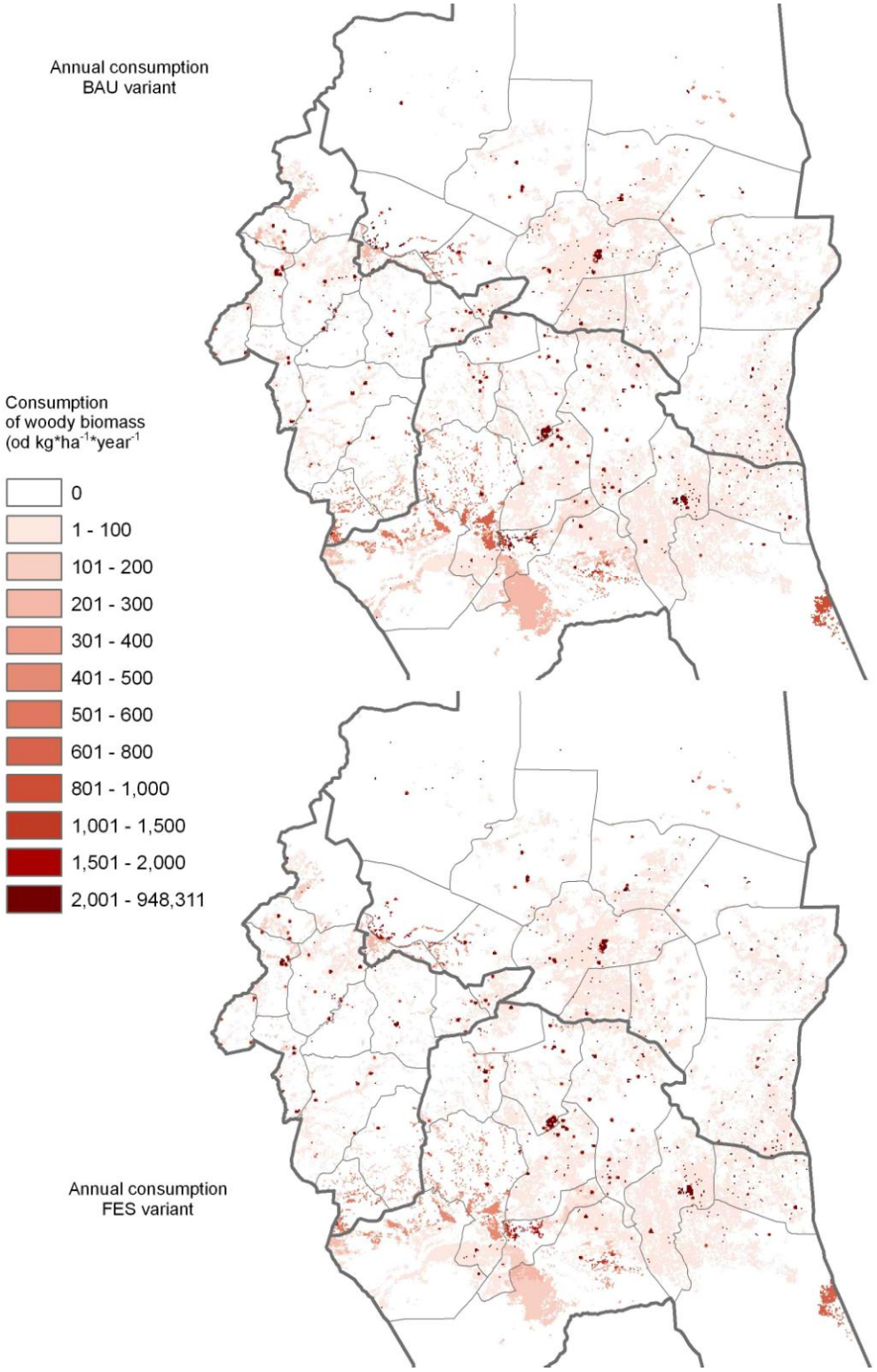
With a simplistic approach, the economic viability of woodfuel production was here limited to the definition of the threshold in the quantity of woody biomass that may be (sustainably) extracted by hectare, with or without a profit. Below such a threshold the available woody biomass may be considered accessible only for a local non-commercial context, largely represented by the self gathering of fuelwood for own consumption, but not to feed a formal woodfuel market of charcoal and fuelwood.

Such thresholds depends on local conditions, such as price of fuelwood and charcoal and level of demand and on the distance from the market place from the resources. A common reliable source of information in this case are the charcoal makers, who can tell what is the minimum amount of wood within a certain distance from the kiln to make the work profitable. This minimum quantity is then put in relation with the annual sustainable productivity and the rotation period estimated necessary for the land cover type to achieve such quantity. In absence of quantitative references, several thresholds were applied and the results reviewed (see below in 4.3.3.2 Balance in a local context and “commercial” balance).

4.3 Results

4.3.1 Demand for woody biomass

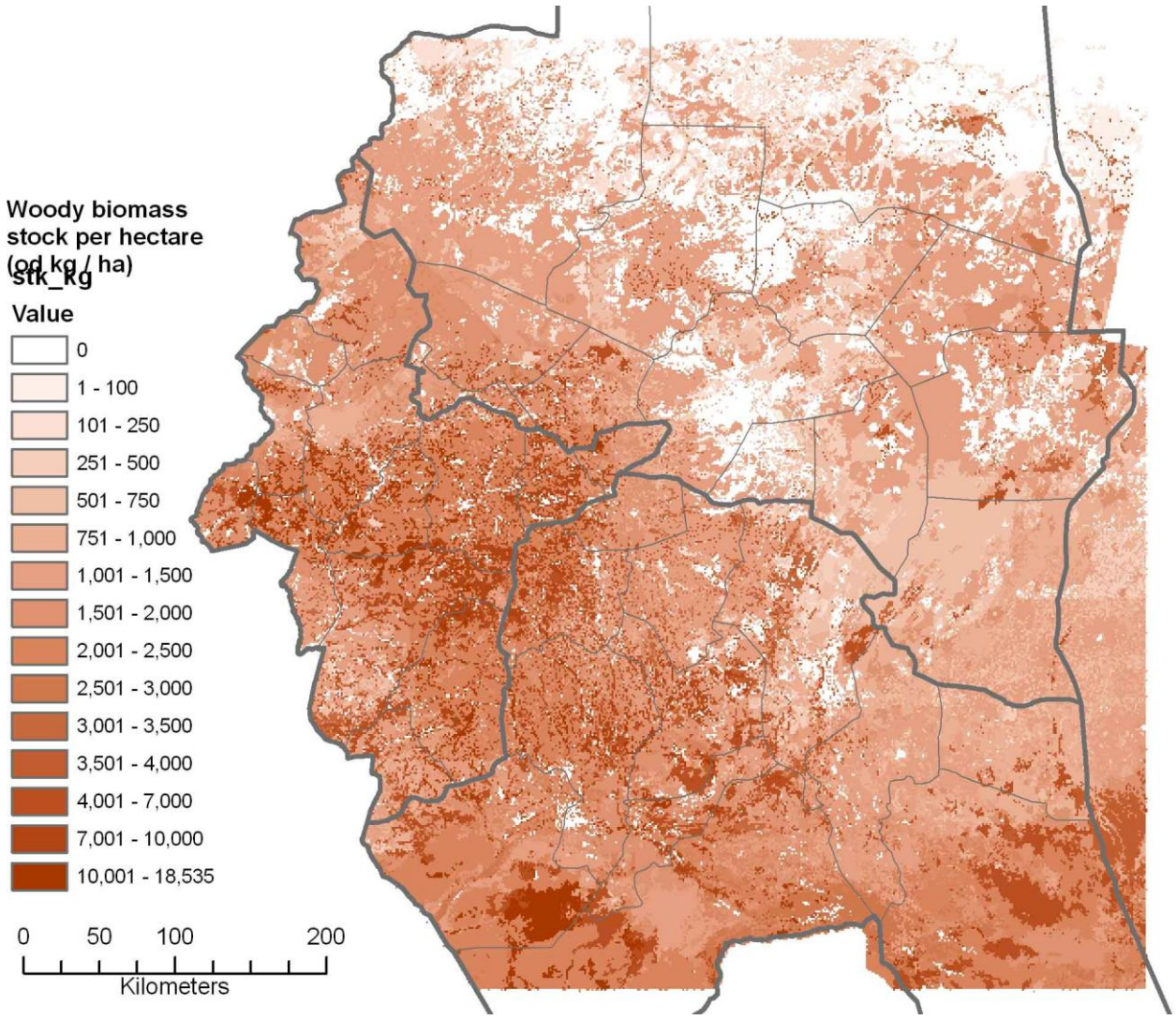
Figure 13: Woody biomass consumption maps. Top map: BAU variant. Bottom map: FES variant, assuming a strong and efficient dissemination of fuel-efficient stoves in rural and urban areas.



4.3.2 Woody biomass supply potential

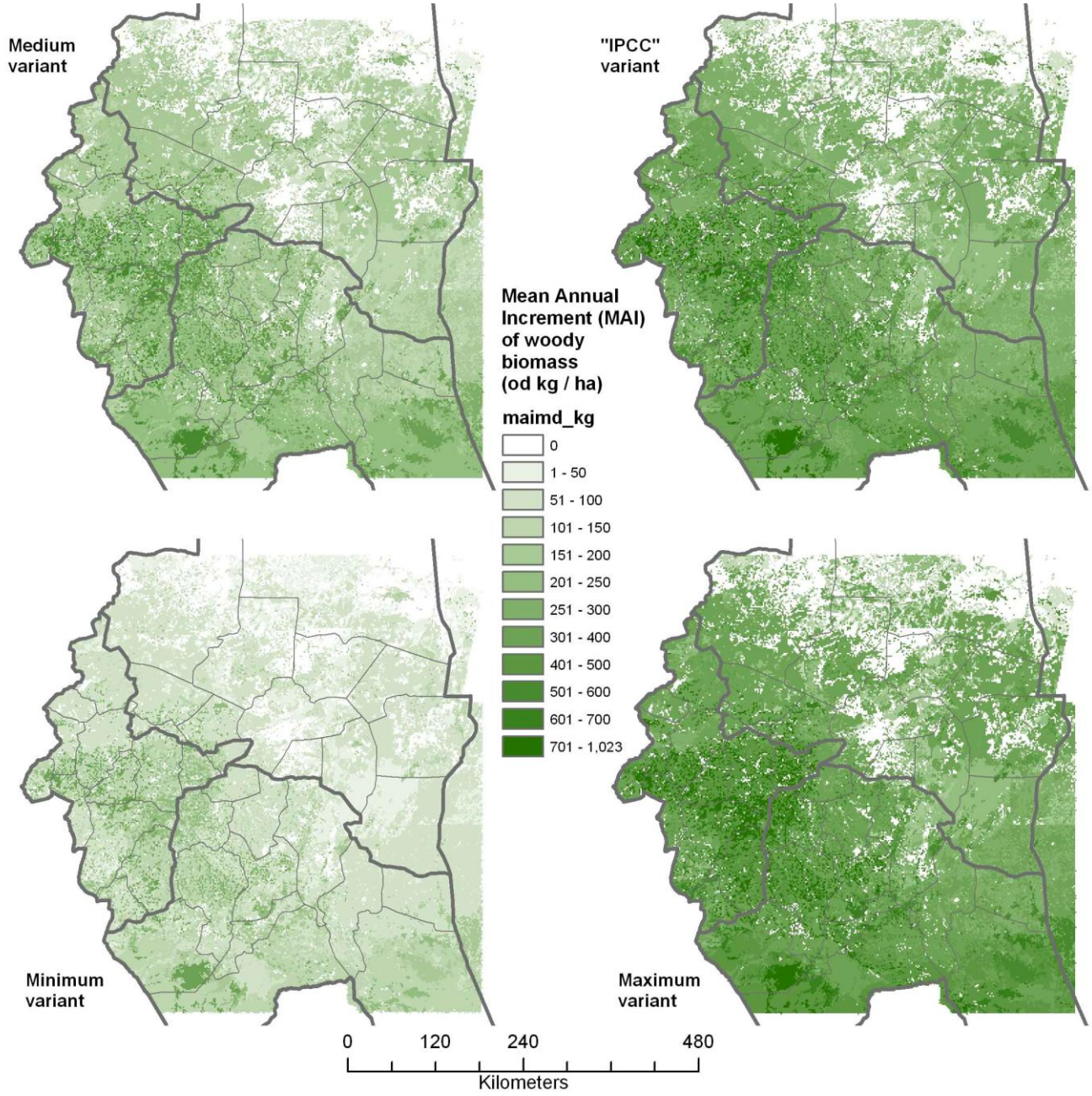
4.3.2.1 Stock

Figure 14: Stock of woody biomass.



4.3.2.2 Productivity

Figure 15: Mean Annual Increment of woody biomass according to 4 different productivity rates. The Medium variant (top left map), is the one considered more reliable and most frequently used in the subsequent phases of analysis.



4.3.2.3 Physically accessible productivity

Figure 16: Map of MAI-Medium variant (top map) and its estimated physically accessible fraction (bottom map).

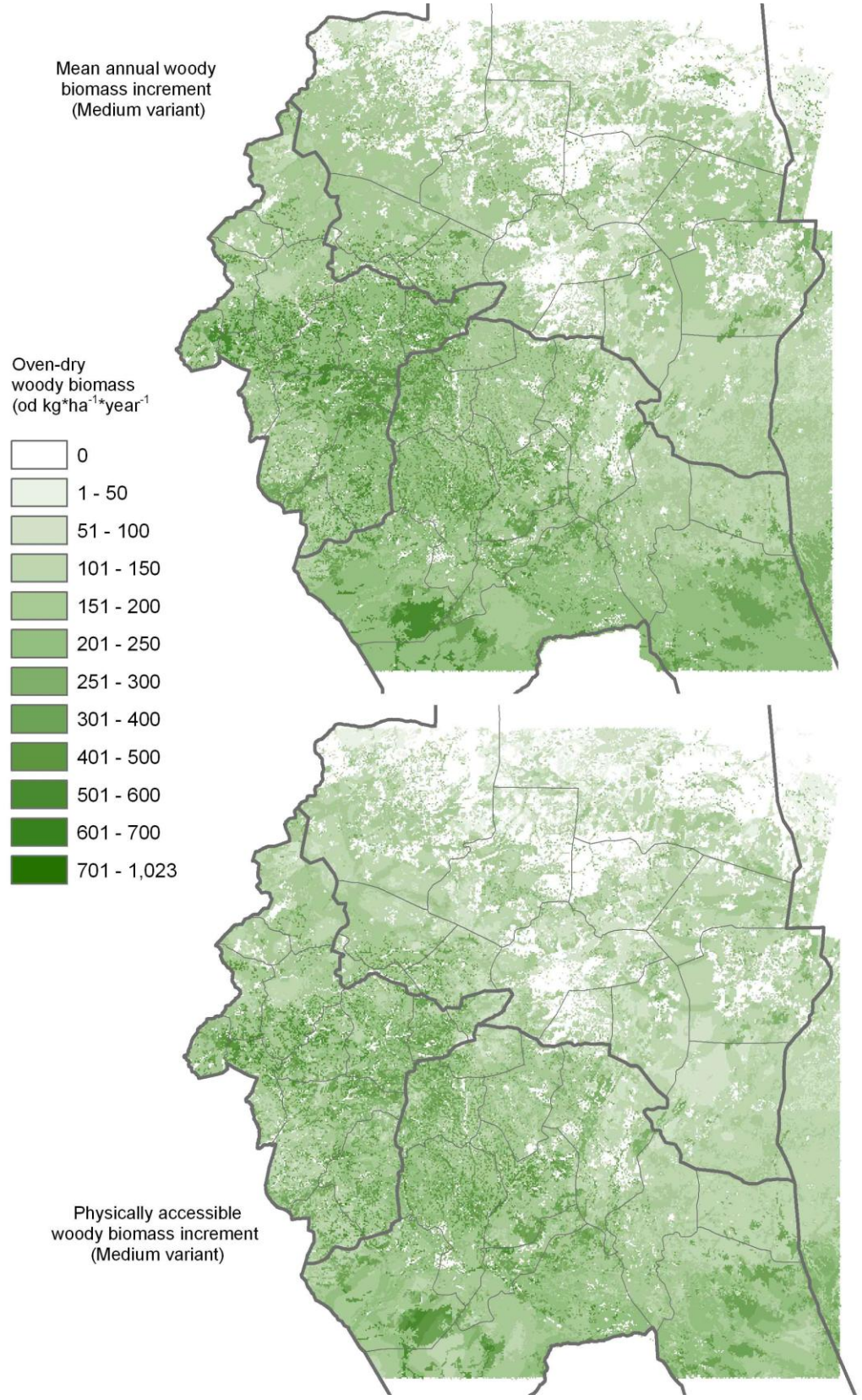


Table 5: Woody biomass stock and potential productivity statistics by Localities and States (values = oven-dry tons)

State_EN	code	Locality_Name	km2	Woody biomass stock)	MAI Minimum variant	MAI Medium variant	MAI Maximum variant	MAI "IPCC" variant	Access. Prod Min	Accessible Productivity Med-var. (od t)	Access. Prod Max	Access. Prod "IPCC"
	6101	Almalha	28,344	1,207,430	83,864	182,752	372,916	340,870	68,308	148,318	304,326	278,218
	6102	Milleet	8,332	551,602	35,902	76,943	154,421	140,294	32,096	68,585	138,143	125,491
	6103	Eltina	25,118	1,673,120	111,382	238,351	476,963	433,141	98,495	209,815	420,797	381,900
	6104	Saraf-omra	1,486	298,011	13,831	27,198	51,087	45,488	13,149	25,808	48,510	43,197
	6105	Alsiraif	6,211	1,077,950	56,706	114,373	218,991	196,130	49,930	100,296	192,213	172,121
	6106	Kabkabiya	4,347	1,061,550	46,535	90,597	169,041	150,170	38,343	74,631	139,754	124,234
N_Darfur	6107	Kotum	14,010	1,030,090	66,985	142,763	284,636	258,191	57,996	122,999	245,813	222,881
	6108	Alkoama	7,899	868,828	53,928	113,299	222,934	201,275	45,863	96,109	189,824	171,393
	6109	Alfashir	11,617	787,921	53,630	115,533	232,749	211,717	48,657	104,570	211,496	192,381
	6110	Omkaddadah	13,428	1,339,710	82,660	173,551	342,181	309,124	71,297	149,366	295,656	267,159
	6111	Kalamando	7,150	582,695	40,779	88,397	178,989	162,974	37,346	80,717	164,080	149,393
	6112	Altowaisha - Alliayied	13,680	1,209,270	85,714	185,585	374,915	341,417	77,516	166,970	338,204	307,907
	6113	Dar Elsalam	2,971	139,823	10,105	22,023	44,794	40,879	9,713	21,113	43,082	39,309
	6201	Koulbos	6,869	1,056,940	58,985	120,337	232,265	208,510	52,289	106,494	206,045	185,001
	6202	Sirba	1,973	272,914	15,788	32,358	62,611	56,252	13,365	27,329	53,036	47,659
	6203	Kirainik	5,816	1,623,740	66,356	127,522	235,195	208,259	60,446	116,226	215,085	190,588
	6204	Alginaina	2,752	794,714	31,860	60,899	111,819	98,838	28,754	54,962	101,177	89,479
	6205	Baidah	1,813	651,615	24,245	45,173	81,326	71,398	21,836	40,754	73,609	64,681
	6206	Habeela	3,100	1,129,580	40,967	76,351	137,404	120,673	37,420	69,636	125,520	110,243
W_Darfur	6207	Azoom	3,215	1,482,440	50,440	92,108	162,841	142,187	41,082	75,072	133,198	116,395
	6208	Zalingay	6,170	2,146,590	83,047	155,790	281,237	247,090	72,635	135,990	245,794	215,972
	6209	Nairtaty	2,366	957,961	35,188	64,986	115,830	101,303	30,681	56,494	100,695	88,042
	6210	Rokoro	1,545	375,112	16,793	32,779	61,177	54,353	13,118	25,512	47,701	42,377
	6211	Wadi-Salih	8,733	2,985,570	114,638	215,384	389,991	343,080	96,535	181,949	331,446	292,011
	6212	Wadi-Salih	6,257	2,267,140	86,949	163,176	294,588	258,913	72,130	135,638	246,072	216,521
	6213	Omdukhon	2,693	699,839	30,214	58,623	108,846	96,550	28,122	54,474	101,378	89,942
	6301	Shiairyya	12,395	1,581,420	87,964	181,229	353,166	317,957	84,711	174,287	340,548	306,635
	6302	Niyala	5,598	841,735	46,713	95,440	184,143	165,254	44,834	91,478	176,862	158,711
	6303	Jabal-Marra East	2,878	587,519	28,873	57,381	108,519	96,779	23,860	47,266	89,513	79,810
	6304	Kass	5,425	1,836,990	73,027	137,530	249,072	219,028	64,929	122,339	222,253	195,570
	6305	Id-Alfursaan	9,947	3,042,760	125,292	238,490	435,868	384,461	119,875	227,858	416,921	367,749
S_Darfur	6306	Alssalam	7,232	2,059,970	85,197	163,010	299,327	264,424	82,028	156,745	288,200	254,585
	6307	Aldiain	8,707	1,144,570	68,861	143,052	279,786	252,105	65,502	135,731	266,119	239,829
	6308	Adeela	6,308	748,636	46,659	98,373	194,737	176,196	44,879	94,282	187,114	169,342
	6309	Tolus	3,865	1,046,140	45,322	87,292	160,969	142,410	42,552	81,895	151,317	133,892
	6310	Rihaid-Albirdi	12,717	4,458,500	171,555	323,147	585,305	515,147	152,414	287,485	522,883	460,555
	6311	Booram	17,411	4,758,010	210,517	407,105	752,093	665,775	188,002	363,147	672,511	595,480
	6312	Bahr-Alarab	19,491	4,937,380	229,407	446,890	830,614	736,383	208,570	405,804	756,030	670,492
		North Darfur	144,593	11,828,000	742,020	1,571,366	3,124,616	2,831,671	648,709	1,369,296	2,731,898	2,475,583
		West Darfur	53,303	16,444,155	655,471	1,245,486	2,275,130	2,007,406	568,412	1,080,529	1,980,756	1,748,910
		South Darfur	111,973	27,043,630	1,219,387	2,378,939	4,433,599	3,935,919	1,122,156	2,188,317	4,090,271	3,632,650
		Tot Darfur (study area)	309,869	55,315,785	2,616,877	5,195,791	9,833,345	8,774,995	2,339,277	4,638,142	8,802,924	7,857,143

4.3.3 Supply / demand balance

4.3.3.1 Pixel-level balance

Figure 17: Pixel-level supply/demand balance assuming medium productivity and BAU consumption

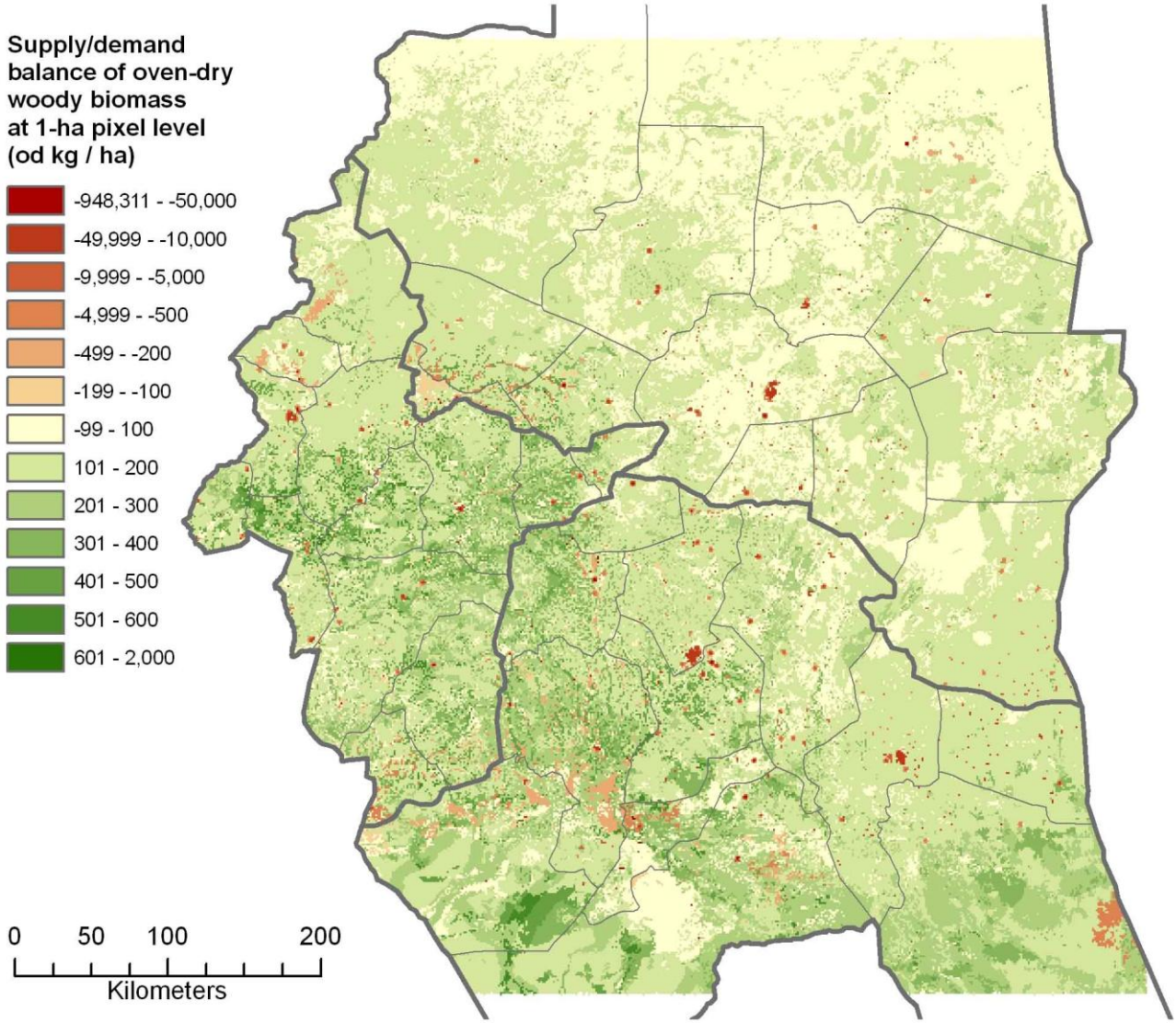
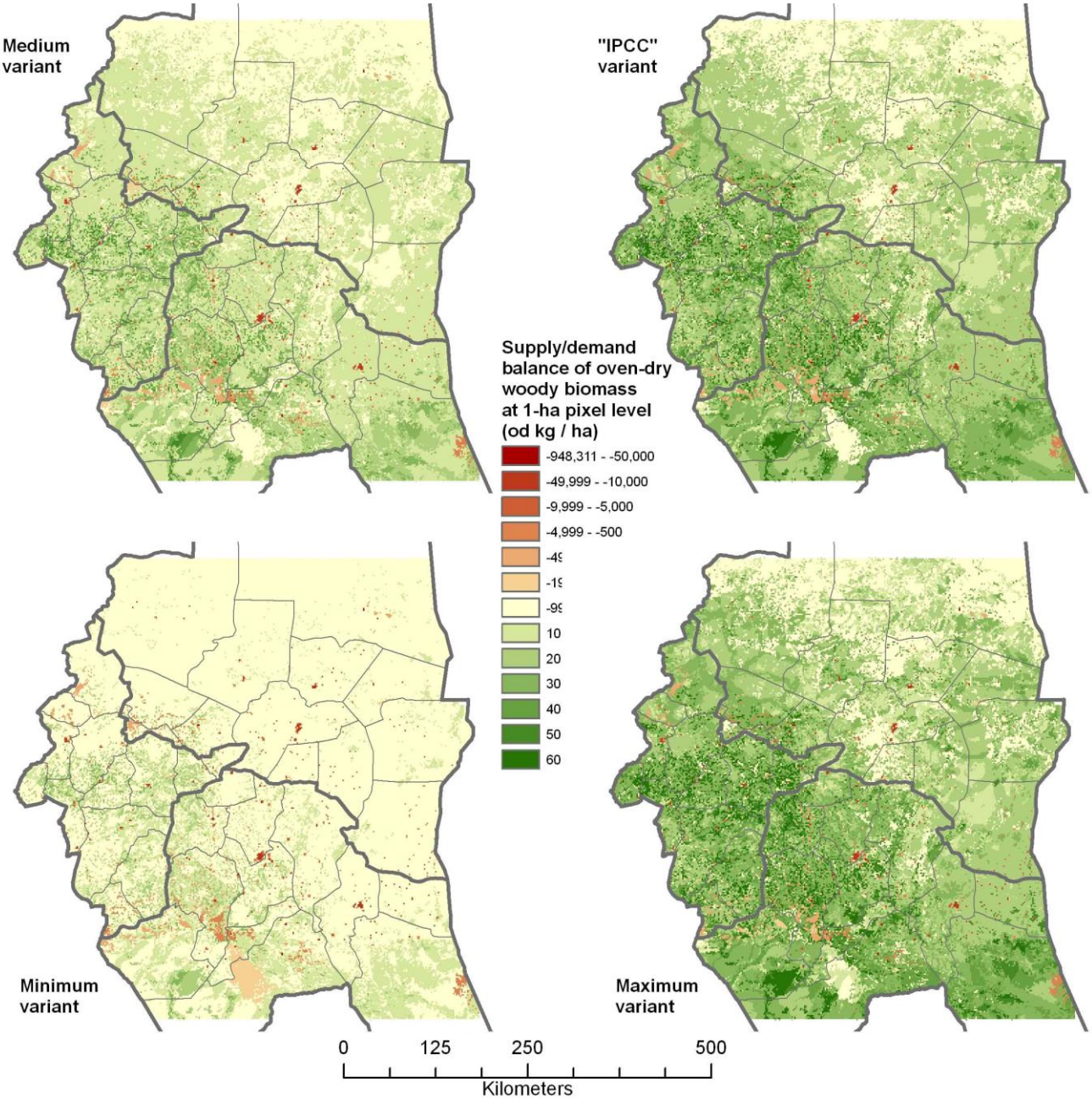
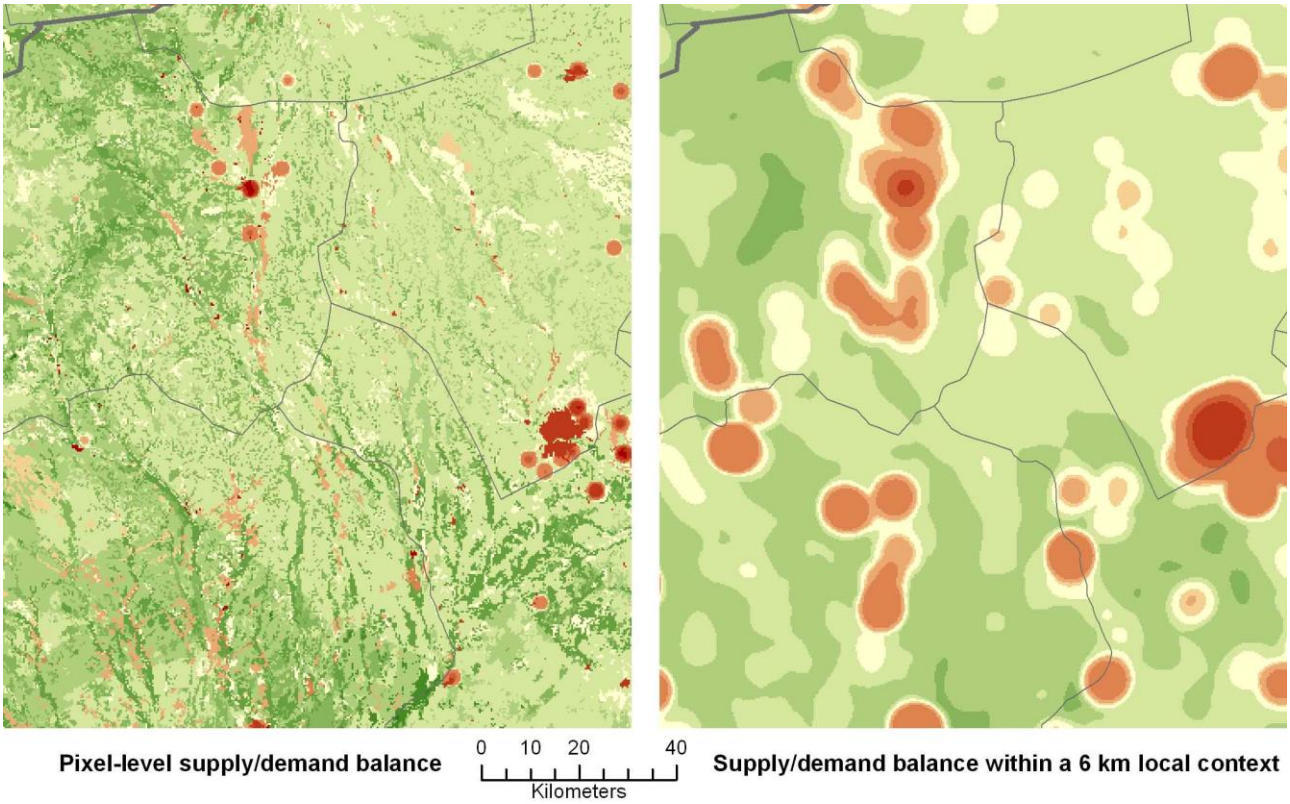


Figure 18: Balance maps resulting from the adoption of various productivity variants. From the Demand side, all these maps refer to the “business as usual” (BAU) variant.



4.3.3.2 Balance in a local context and "commercial" balance

Figure 19: Balance calculated on a pixe-level basis (left map) and on a 6-km local context (right map)



Commercial balance and economically accessible resources

Considering that the management and commercial exploitation of sparse resources may be uneconomical, several balance analyses were carried out of "economically accessible" resources by application of different minimum resource availability thresholds to local surpluses, and deficits, resulting from the balance analyzed in a 6-km local context. The results, shown in Figure 20 and summarized in Table 4, indicate the following:

- By applying a minimum availability threshold of 200 kg/ha/yr to the surplus remaining after local consumption (= 3 od tons / ha on a 15-years rotation), the "commercial" balance so determined shows an overall deficit of -980 thousand od tons, with state-level values of -621 for North Darfur, -452 for South Darfur and + 93 for West Darfur. This indicates that such threshold can only be applied in West Darfur
- By applying a minimum availability threshold of 150 kg/ha/yr (= 2.25 od tons / ha on a 15-years rotation), the "commercial" balance shows an overall deficit of -83 thousand od tons, with state-level values of -468 for North Darfur, +35 for South Darfur and +350 for West Darfur. This indicates that such threshold mai be applied in West and South Darfur but not in the North.
- By applying a minimum availability threshold of 100 kg/ha/yr (= 1.5 od tons / ha on a 15-years rotation or 1 od ton on a 10 years rotation), the "commercial" balance shows an overall surplus of +817 thousand od tons, with state-level values of +38 for North Darfur, +301 for South Darfur and +478 for West Darfur. This indicates that with such low threshold the production would match the demand over the entire territory.

Different thresholds may be applied in the states but most important will be to verify the economic viability of the various situations with local operators and managers and to complement the supply strategies with planting where feasible and to reduce the demand by fuel substitutions and FES programmes.

Figure 20: Supply/demand balance within a local context (top map) and "commercial" balance maps applying surplus thresholds of 200, 150 and 100 kg/ha/year.

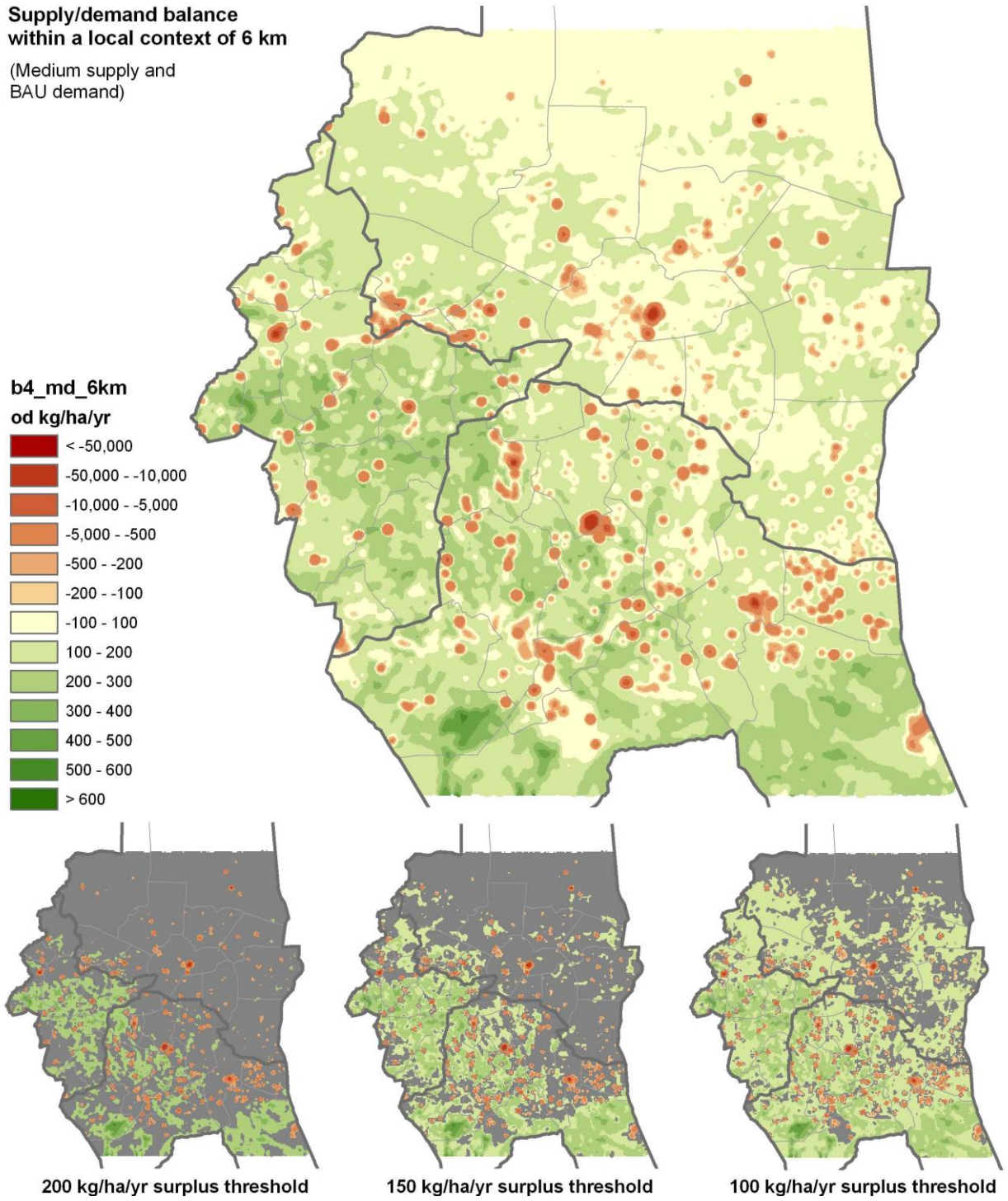


Table 6: State-level "commercial" balance applying thresholds of 200, 150 and 100 kg/ha/year ('000 od t)

	surplus >200kg	surplus >150kg	surplus >100kg
North Darfur	-621	-468	38
West Darfur	93	350	478
South Darfur	-452	35	301
Tot Darfur (study area)	**-980**	**-83**	**817**

4.3.3.3 Summary statistics by Localities

The summary statistics resulting from the analysis are presented by Localities, whose layout is shown in Figure 21. To be noted that the study area was determined by the limits of the new land cover map (in grey in Figure 21. Consequently, the results for the localities in the extreme north and in the extreme south do not cover the entire administrative areas.

Figure 21: Darfur State and Localities over the study area of the Detailed WISDOM analysis (in grey).

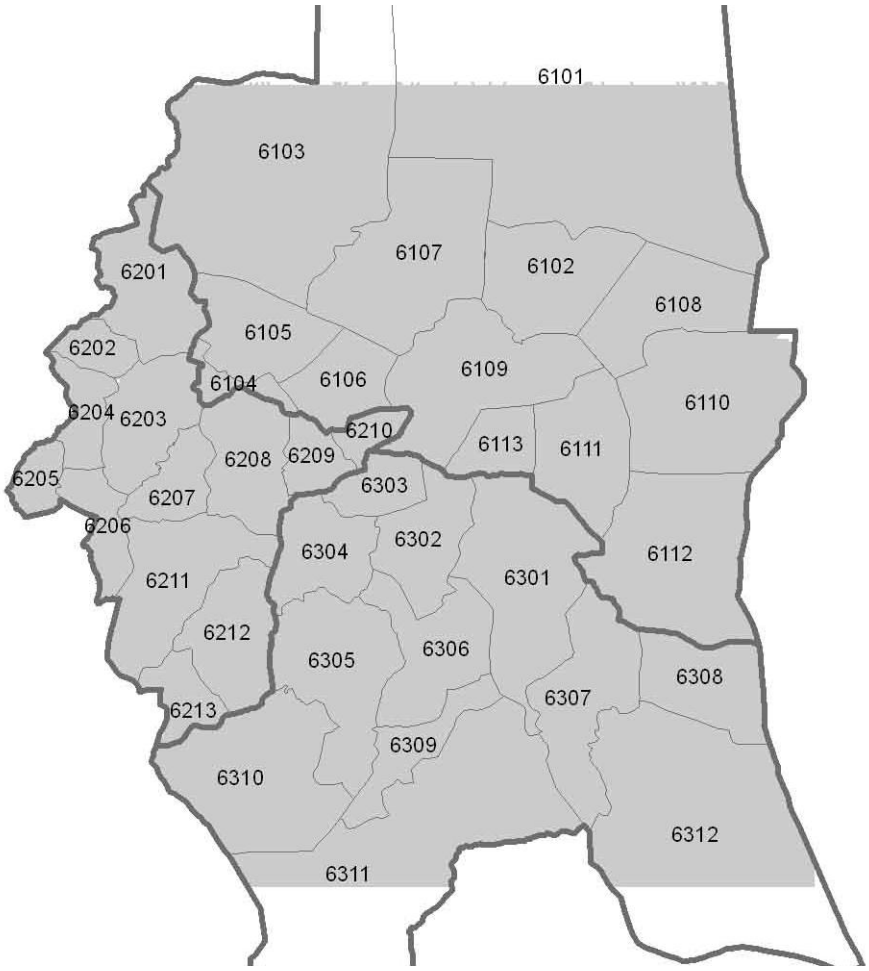


Figure 22: Maps of supply/demand balance by Administrative Unit (subdivisions of Localities) according to medium productivity variant and demand variants BAU (top map) and FES (bottom map). Summary statistics by Localities are reported in Table 7.

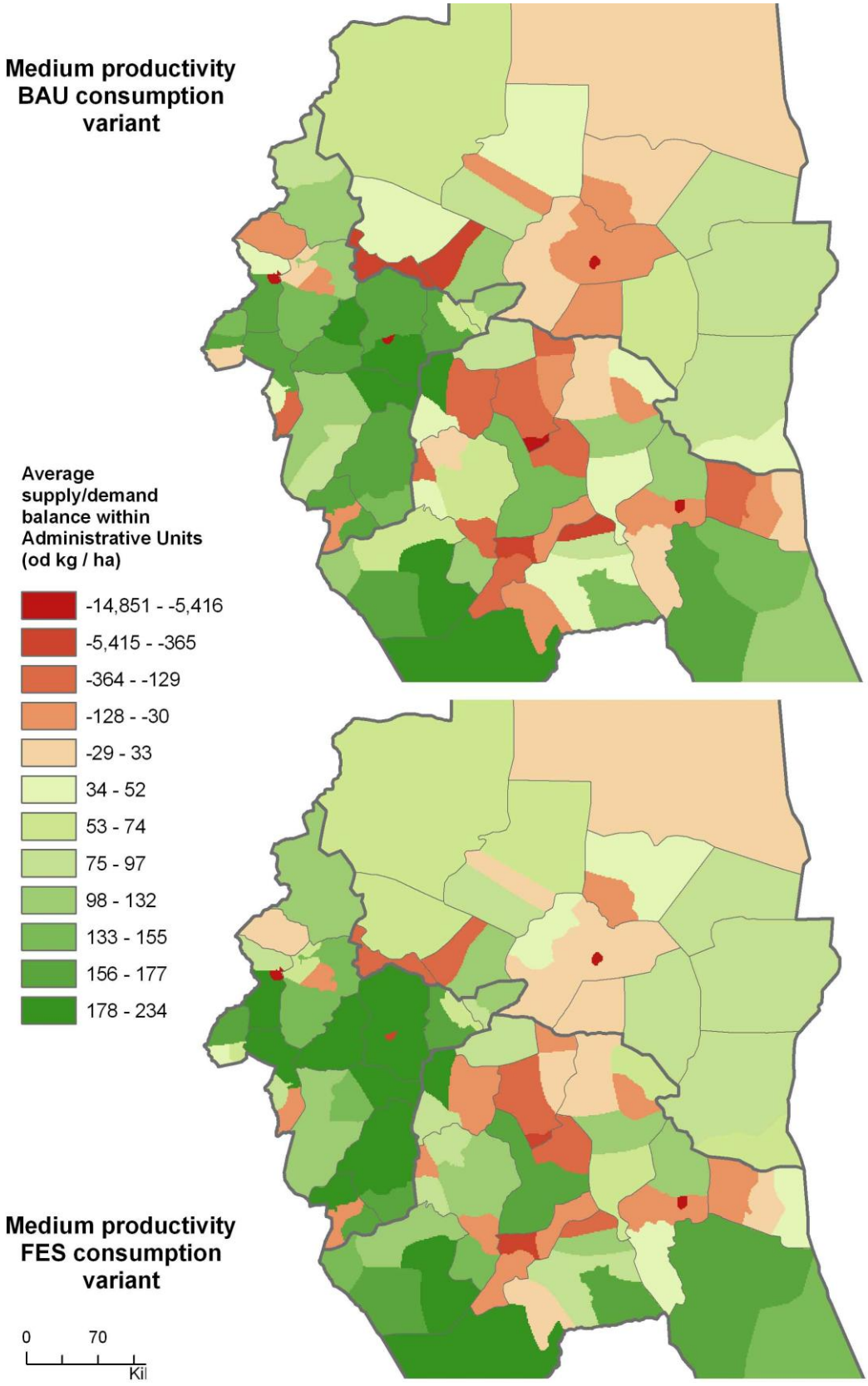


Table 7: Summary supply/demand balance statistics by Localities and States

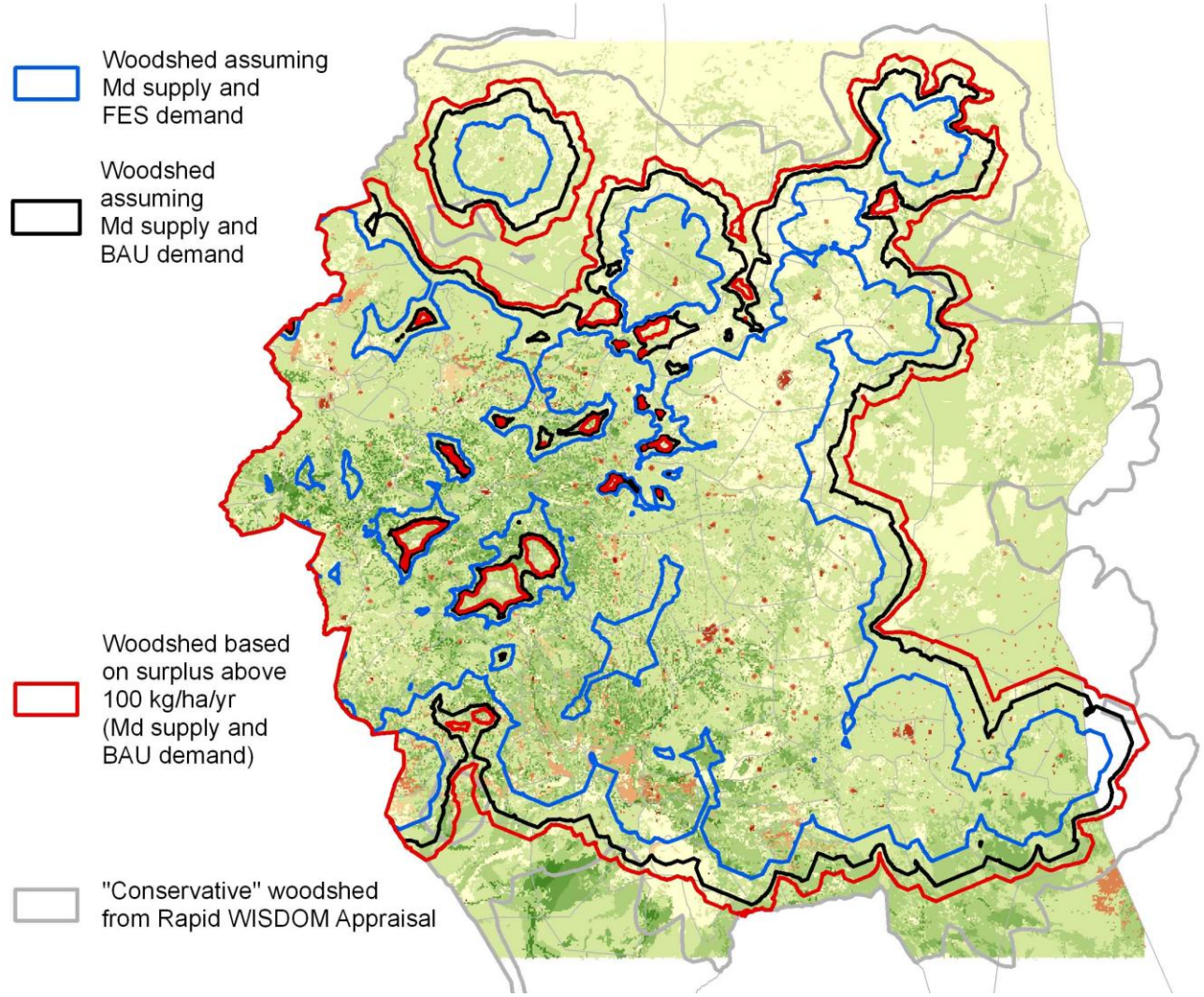
State_EN	code	Locality_Name	Accessible Productivity Med-var. (od t)	Consumption BAU variant (od t)	Consumption FES variant(od t)	Balance Md-BAU (od t)	Balance Md-FES (od t)	"commercial" balance on 6km-surplus >200kg (Med- BAU)	"commercial" balance on 6km-surplus >150kg (Med- BAU)	"commercial" balance on 6km-surplus >100kg (Med- BAU)
	6101	Almalha	148,318	78,633	58,925	69,685	89,393	-69,887	-62,871	-29,522
	6102	Milleet	68,585	67,694	54,306	891	14,279	-31,674	-29,396	-10,226
	6103	Eltina	209,815	34,705	26,835	175,110	182,980	-20,698	1,631	111,410
	6104	Saraf-omra	25,808	104,257	80,003	-78,449	-54,195	-72,181	-71,129	-69,678
	6105	Alsiraif	100,296	75,058	56,361	25,238	43,935	-35,759	291	29,418
	6106	Kabkabiya	74,631	109,436	88,809	-34,806	-14,178	-78,840	-55,902	-37,838
N_Darfur	6107	Kotum	122,999	62,310	53,854	60,690	69,145	-40,303	-26,342	15,440
	6108	Alkoama	96,109	33,971	25,722	62,137	70,387	-22,793	-2,165	50,895
	6109	Alfashir	104,570	271,262	229,030	-166,692	-124,459	-212,091	-209,785	-180,408
	6110	Omkaddadah	149,366	43,433	32,922	105,934	116,445	-7,945	10,194	80,422
	6111	Kalamando	80,717	34,480	25,700	46,237	55,016	-5,349	-1,455	25,234
	6112	Altowaisha - Alliayied	166,970	65,686	49,510	101,284	117,460	-9,260	-5,965	67,225
	6113	Dar Elsalam	21,113	33,300	26,652	-12,187	-5,539	-13,791	-14,784	-14,584
	6201	Koulbos	106,494	30,173	23,384	76,321	83,110	-7,401	38,171	72,008
	6202	Sirba	27,329	39,418	31,916	-12,089	-4,586	-25,915	-19,587	-11,182
	6203	Kirainik	116,226	57,543	50,275	58,682	65,951	10,206	35,054	52,365
	6204	Alginaina	54,962	125,159	108,225	-70,198	-53,264	-87,051	-79,244	-73,536
	6205	Baidah	40,754	23,403	18,359	17,351	22,395	7,845	16,900	17,861
	6206	Habeela	69,636	46,284	36,833	23,351	32,802	3,002	14,220	20,308
W_Darfur	6207	Azoom	75,072	18,652	14,270	56,420	60,802	40,972	54,650	55,715
	6208	Zalingay	135,990	54,714	47,653	81,276	88,338	28,431	58,572	65,720
	6209	Nairtaty	56,494	23,875	22,796	32,619	33,698	23,555	29,825	32,181
	6210	Rokoro	25,512	8,549	7,877	16,963	17,636	625	5,027	13,701
	6211	Wadi-Salih	181,949	71,305	58,126	110,644	123,823	54,335	93,900	113,465
	6212	Wadi-Salih	135,638	32,242	25,000	103,397	110,639	45,985	90,712	100,585
	6213	Omdukhon	54,474	29,255	23,232	25,218	31,242	-1,574	12,066	18,949
	6301	Shiairyya	174,287	138,780	115,544	35,507	58,744	-61,029	-22,836	18,696
	6302	Niyala	91,478	326,170	280,643	-234,692	-189,165	-280,589	-242,259	-226,954
	6303	Jabal-Marra East	47,266	24,482	23,294	22,784	23,972	-12,707	4,739	17,745
	6304	Kass	122,339	133,405	111,574	-11,066	10,765	-36,917	-14,276	-10,295
	6305	Id-Alfursaan	227,858	200,845	153,580	27,013	74,279	-36,668	8,016	21,315
S_Darfur	6306	Alssalam	156,745	129,595	112,700	27,151	44,045	-35,094	-1,824	11,230
	6307	Aldiain	135,731	199,226	166,157	-63,495	-30,426	-153,773	-126,916	-71,002
	6308	Adeela	94,282	134,721	103,367	-40,439	-9,085	-75,440	-67,909	-41,910
	6309	Tolus	81,895	165,646	129,105	-83,751	-47,210	-98,264	-90,101	-84,476
	6310	Rihaid-Albirdi	287,485	100,861	77,258	186,624	210,227	92,146	158,796	181,859
	6311	Booram	363,147	216,864	175,878	146,283	187,269	52,730	144,643	172,103
	6312	Bahr-Alarab	405,804	116,526	88,596	289,279	317,209	193,591	284,595	312,413
		North Darfur	**1,369,296**	**1,014,225**	**808,628**	**355,072**	**560,670**	**-620,572**	**-467,676**	**37,787**
		West Darfur	**1,080,529**	**560,574**	**467,945**	**519,957**	**612,585**	**93,015**	**350,265**	**478,141**
		South Darfur	**2,188,317**	**1,887,121**	**1,537,696**	**301,198**	**650,623**	**-452,014**	**34,669**	**300,723**
		Tot Darfur (study area)	**4,638,142**	**3,461,919**	**2,814,269**	**1,176,226**	**1,823,878**	**-979,571**	**-82,742**	**816,650**

4.3.4 Woodshed analysis

4.3.4.1 Darfur context

Figure 23 shows the theoretical woodshed zones assuming medium productivity variant, BAU and FES demand variants, and the sustainable management of all wood resources. This is obviously theoretical since many formations are too scarce in woody biomass to justify management costs. In order to determine a more realistic supply zone, a minimum per hectare resource must be determined. The setting of such limit to 200 kg/ha/yr (which means approximately 3 tons of harvestable wood per hectare on a 15-years rotation) shows that the demand cannot be met, with a deficit of one million tons. If the limit is posed at 100 kg/ha/yr (which means approximately 1.5 tons of harvestable wood /ha on a 15-years rotation or 1 ton on a 10-years cycle) the balance become positive and the woodshed size as shown in Figure 23 (red limits) and reported in Table 8.

Figure 23: Woodsheds of Darfur's IDP camps according to BAU and FES consumption scenarios as well as to a minimum "commercial" biomass threshold of 100 od kg/ha/year. See Table 8 for summary statistics.



4.3.4.1 IDP Camps context

Figure 24: IDP camps' woodshed with pre-defined cost-distance values. In the example shown the value assumed is 36 km on a flat accessible terrain or equivalent effort over rough and steep terrains. The supply/demand balance within these woodsheds and an estimation of the non-renewable fraction of the consumed woody biomass is given in Table 9.

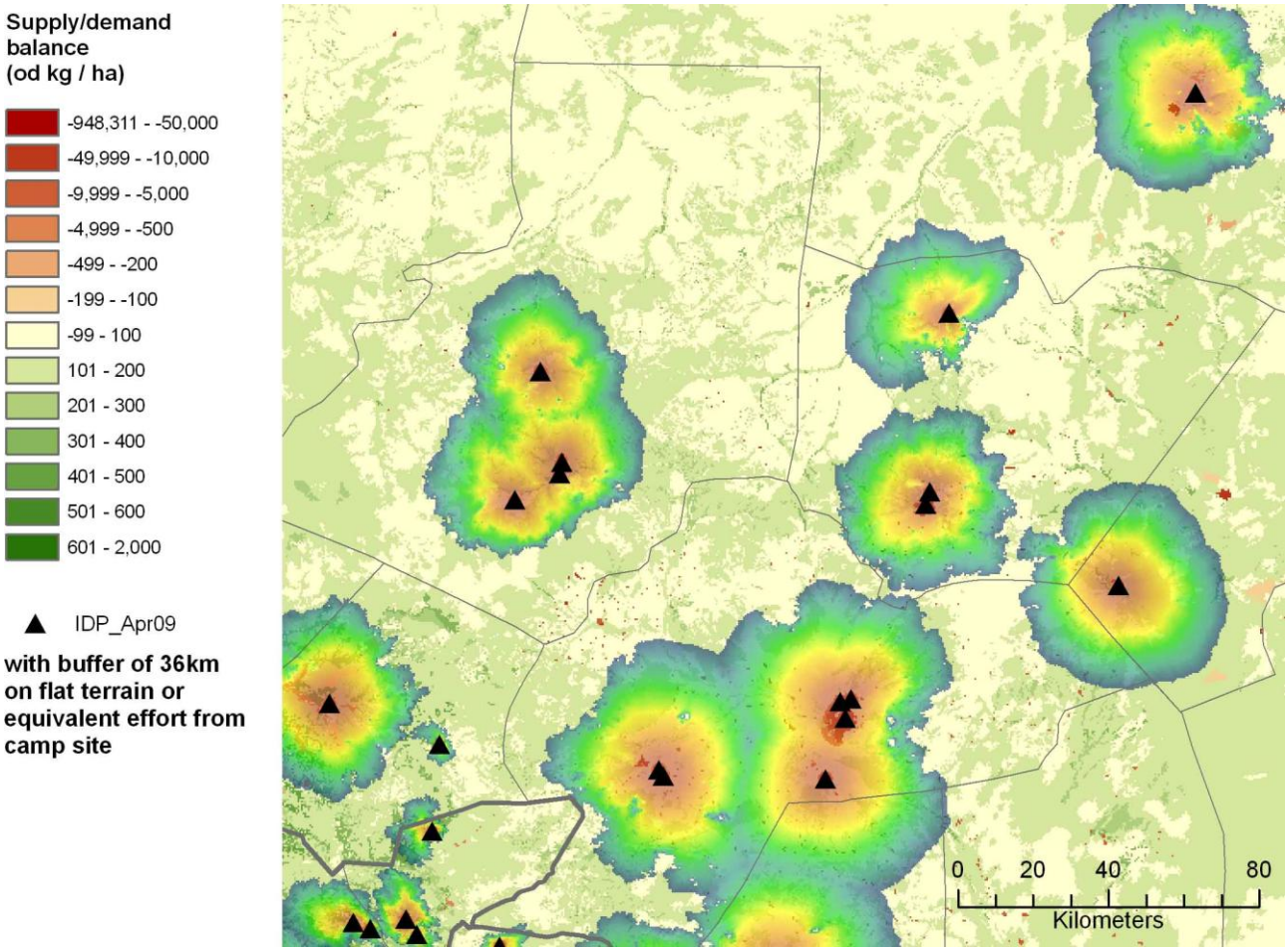


Table 8: Summary statistics of the woodshed areas delineated in Figure 23.

	Cumulative area km2	Cumulative population	Cumulative consumption BAU variant '000 od t	Cumulative consumption FES variant '000 od t	Cumulative accessibile supply MED variant '000 od t	Cumulative balance MED-FES '000 od t	Cumulative balance MED-BAU '000 od t	Cumulative local balance (6km) with +-100kg thr. '000 od t	Cumulative local balance (6km) with +-150kg thr '000 od t	Cumulative local balance (6km) with +-200kg thr '000 od t
woodshed 1	136,384	6,182,853	2,814	2,327	2,377	**50**	-437	-530	-880	-1,364
woodshed 2	187,287	6,802,151	3,119	2,556	3,129	573	**10**	-148	-674	-1,310
woodshed 3	209,144	7,028,801	3,230	2,640	3,424	784	194	**6**	-590	-1,275
whole area	309,651	7,490,935	3,462	2,814	4,638	1,823	1,176	817	-83	-980

Table 9: Analysis of supply/demand balance and non-renewable biomass (NRB) within pre-determined woodshed areas around IDP Camps. The distance from the camps considered are 36 km over accessible flat terrain or an equivalent effort over rough and steep terrains.

					Business as usual (BAU) consumption variant			**Intensive Fuel Efficient Stove (FES) variant**		
	Distance from camps or equivalent effort	km2	Supply Md	cumulative Supply Md	cumulative BAU Consumption	cumulative Med-BAU balance	**NRB fraction**	cumulative FES Consumption	cumulative Med-FES balance	**NRB fraction**
N_Darfur	< 13 km	4,922	53,042	53,042	448,984	-395,942	**0.882**	381,512	-328,323	**0.861**
N_Darfur	13 - 24 km	10,193	113,750	166,792	576,572	-409,780	**0.711**	477,924	-310,774	**0.651**
N_Darfur	24 - 36 km	12,516	138,745	305,537	661,781	-356,244	**0.538**	541,749	-235,679	**0.436**
W_Darfur	< 13 km	8,742	172,427	172,427	413,231	-240,804	**0.583**	357,698	-185,126	**0.518**
W_Darfur	13 - 24 km	14,297	290,014	462,441	474,706	-12,265	**0.026**	404,418	58,276	**0.000**
W_Darfur	24 - 36 km	13,055	261,031	723,471	524,700	198,771	**0.000**	441,879	281,937	**0.000**
S_Darfur	< 13 km	17,694	334,005	334,005	1,053,110	-719,105	**0.683**	906,626	-572,343	**0.632**
S_Darfur	13 - 24 km	26,414	502,457	836,462	1,356,863	-520,401	**0.384**	1,136,574	-299,516	**0.264**
S_Darfur	24 - 36 km	21,223	397,652	1,234,114	1,581,218	-347,104	**0.220**	1,305,784	-70,850	**0.055**

5 Conclusions and recommendations

5.1 Findings and conclusions

WISDOM Darfur is conceived as a strategic planning tool to be maintained, deepened and, most important, used by forestry, energy and rural development planners, emergency and relief operators, etc., concerned with wood energy planning, environmental impact assessment, integrated land management, etc..

The analytical conclusions, thematic maps and tables here presented should be considered as the first step in the analysis of this sector and not its conclusion. The effort of creating a comprehensive vision in spite of current data limitations implied several assumption and values attributions that are here openly presented and that need to be replaced by objective data, when available, in order to reduce the margin of approximation and improve overall analytical accuracy.

Moreover, further layers of analysis may be included, linking woodfuel deficit to poverty and vulnerability, or exploring the nexus between woodfuel deficit, the use of farm residues as fuel versus livestock feeding on one side and soil fertility on the other.

Main findings

Demand for woody biomass

- The total annual consumption of woody biomass, all uses included, is estimated at 5.9 million m^3, or 3.5 million oven-dry tons
- With 93 % of the total woody biomass use, the household sector is by far the most important demand sector. This value is higher in rural areas (98%) and lower in urban areas (77%), where industrial uses are concentrated. 86% of the household consumption goes to cooking and the rest to construction, maintenance and furniture. This value is lower in rural areas (83%) and higher in urban areas (95%).
- The big building wave consequent to the influx of the international community, which boosted brick production to extreme levels, seems to have passed but the impact of this use sector remains serious. The present study assumes an annual fuelwood consumption of over 100,000 m^3, which is less than the wave peak but 4 times higher than pre-war situation.
- The consumption by the Institutional, commercial and industrial sectors (bricks included) is estimated at 416,000 m^3
- The dissemination of Fuel Efficient Stoves (FES), which is one of the ways to reduce the consumption of fuelwood and provide other benefits, has been done in IDP camps with good results but only marginally in rural and urban areas. It is estimated that a widespread and intensive FES programme in rural and urban areas may reduce the total consumption by a maximum of 1.1 million m^3 (from 5.9 to 4.8 million m^3, or from 3.5 to 2.8 million oven-dry tons).

Woody biomass supply potential

- The total stock of woody biomass in the Area of Interest (including Darfur states excluding extreme south and desertic north) was estimated at 94 million m^3, or 55 million oven-dry tons.
- The estimated Mean Annual Increment according to the medium productivity variant is 8.8 million m^3, or 5.2 million oven-dry tons.
- The physically accessible productivity is estimated at 7.9 million m^3, or 4.6 million oven-dry tons.

Supply/demand balance and woodshed analysis

- The supply/demand balance, assuming BAU demand and medium accessible productivity, shows an overall surplus of 1.2 million oven-dry tons. Assuming the full impact of the FES consumption variant, the surplus rises to 1.8 million od tons. These results indicate that there is a theoretical sustainable potential but give no guarantee of economic sustainability (see below). Moreover, these summary results do not reflect the geographic distribution of deficit areas and surplus areas
- Considering that the management and commercial exploitation of sparse resources may be uneconomical, balance analyses were carried out of “economically accessible” resources by application of different minimum resource availability thresholds to local surpluses. The results show that:

  - in North Darfur, in order to match the commercial demand, a minimum threshold of 100 kg/ha/yr (= 1 od tons / ha on a 10-years rotation) must be applied in order to match the commercial demand, which is most likely uneconomical;
  - in West Darfur, a minimum threshold of 200 kg/ha/yr (= 3 od tons / ha on a 15-years rotation) is sufficient to match the commercial demand, which may be economically viable;
  - in South Darfur, a minimum threshold of 150 kg/ha/yr (= 2.25 od tons / ha on a 15-years rotation) must be applied in order to match the commercial demand, whose economic viability is doubtful.

- Woodshed analysis revealed the extent of territory consumption sites (IDP camps, in this case) that must be managed for woodfuel production in order to meet the demand, according to various supply and demand scenarios. When realistic productivity and demand assumptions are adopted, the woodshed expands to include the majority of Darfur territory, highlighting the difficulty of the situation and emphasizing that all users (urban, rural, IDP, industries, etc.) are equally competing for the resource and that the strategies must address them all.
- The analysis of supply/demand balance around IDP camps allowed to determine the probable Non Renewable Biomass (NRB) fraction associated to current supply systems and thus the associated risks of degradation and deforestation. The analysis was done considering distance from the camps of 13, 24 and 36 km (or equivalent efforts over rough terrain), the latter one being indicated as the limit of current supply zone. The results show that:
  - the situation is particularly serious in North Darfur, where the NRB fraction ranges between 88% at close distance and 54% when the maximum distance is considered, with little improvement deriving from hypothetical FES programmes;
  - the best situation is shown by West Darfur where NRB fraction is 58% at close distance but reduces to 0% for a horizon of 24 km;
  - South Darfur presents an intermediate situation, with an NRB fraction of 68% at close distance, reducing to 22% for an harvesting horizon of 36 km.

  The analysis can be carried out for specific locations, i.e. individual IDP camps, in order to assess environmental impacts and to target project action.

Main conclusions

Wood energy issues

- Darfur seems to have the theoretical potential, in terms of mean annual increment (MAI) of woody biomass to produce the woody biomass necessary to satisfy the current demand.
- Spontaneous and unplanned harvesting is impacting on the capital (stock) rather than on its interest rate (MAI), provoking degradation and depletion of natural resources.
- Converting the spontaneous harvesting into sustainable wood energy systems requires major efforts including:
  - intensive and locally tailored participatory management planning,
  - plantation establishment,
  - Fuel Efficient Stoves programmes in rural and urban areas.
- Providing alternative livelihood strategies for rural populations currently dedicated to fuelwood and charcoal production for sale at IDP camp sites are important and beneficial but assuming that this would reduce the pressure on wood resources is probably erroneous. If the demand remains, other would respond and reducing the exploitation in one areas would simply displace it over another area. More efficient would be to rationalize the supply/demand chain by promoting equitable and sustainable resource management, thus consolidating income sources wherever feasible.
- The margin between the demand and the growth potential is limited and the economic viability of sustainable commercial wood energy systems needs to be carefully evaluated. The results show that a positive the supply/demand balance can be met only if formations with very low productivity (and thus with little or no attraction for private operators) are put under operational management.

- The values derived from the application of minimum resource availability thresholds, presented above, give us the context and constraints in which forest management planning must operate. The economic viability of sustainable production systems must be discussed and defined area by area with forest managers and local operators. Where the commercial balance remains negative, the supply strategies must be complemented by tree planting and the demand must be reduced by FES and fuel substitution programmes.
- From all above it is evident that strategy options must be locally tailored in order to be effective, and that the main contribution of the WISDOM tool is in supporting geo-referenced priority zoning under various policy items and assumptions.
- The imminent separation of Sudan into two independent nations will exacerbate the woodfuel deficit of North Sudan, given its high demand and its limited supply sources. The WISDOM analysis over the rest of North Sudan, based on the new land cover map currently under production, will be instrumental in the identification of critical situations and in the definition of remedial strategies.

Communication strategy

- The deep nexus between subsistence energy, livestock management, sustainable forestry and farming requires multi-sectoral strategies based on in a shared analytical context.
- The comprehensive and spatial-explicit vision of supply and demand is a basic pre-requisite to wood energy planning and strategy formulation at local and national levels and synergies among institutions and agencies for an integrated multi-sectoral approach are essential.
- In order to promote institutional awareness on the findings and on the planning support offered by WISDOM Darfur it is necessary to implement a communication strategy aiming at state-level administrators and operators as well as to national institutions, agencies and donors community.

WISDOM data

- Given the limits of existing data, the development of the WISDOM geostatistical database implied many assumptions and tentative value attributions. Competent critics are most welcome, especially if they can correct possible misinterpretation of existing data or if they can indicate new and more reliable references.

Weaknesses of approach/limitations

- WISDOM Darfur is still in its “prototype” version. It provides a comprehensive vision but a user-friendly interface for consultation, updating and maintenance has not yet been developed.
- WISDOM Darfur presents the situation between 2008 and 2009. The vision provided by the current dataset is a “snapshot” that becomes out-of-date with the changing of the situation.
- Concerning the demand module, the main weaknesses are related to the reliability and completeness of demographic data, including regular resident and nomadic populations and IDP. The census subdivision and administrative maps show several inconsistencies and there is a poor correspondence between 2008 census statistics and IDP statistics for the same period.
- Concerning the supply module, the main weakness is due to the absence of reliable data on the mean annual increment and on the sustainable and economically accessible productivity.
- Concerning the Integration module, other thematic layers can and should be added to the analysis in order to identify and delineate priority areas of intervention with cross-sectoral dimension. Most immediate thematic layers may include:
    - Water availability for population, livestock and farming.
    - Livestock presence and transhumance routes.
    - Poverty
    - Vulnerability
    - Access to services (health market schools, etc.)….

5.2 Recommendations

The underlying recommendation to all following is that peace and security return to Darfur. Minimal security conditions are basic pre-requisites to most, if not all, recommended sustainable resource management actions.

Short term recommendations (< 2 years)

- In order to improve the visibility and impact on planning and policy formulation, it is recommended to define and implement a communication strategy. Such strategy should include the following:
    - Prepare a publication on WISDOM Darfur for wide dissemination addressing policy makers as well as documenting the analytical process.
    - Conduct state-level workshops to present WISDOM's findings, discuss the assumptions made and define follow-up actions aiming at the appropriation of the WISDOM tool by state-level institutions and agencies
    - Promote cross-sectoral dialogue and the establishment of an inter-institutional / inter-agencies working group (WISDOM Team) at both technical and policy level through thematic workshops. Scope of such events will be promoting cross-sectoral policy formulation and project planning and sharing/strengthening the knowledge base for decision making
- Define WISDOM data repository and Access policy. Along with the principle of data sharing and transparency, it is recommended to define an operational data handling and storage policy. The institutional repository of the WISDOM dataset will need GIS and database management capacities and training vocation in order to facilitate capacity building along with data dissemination. One promising option in this respect is offered by the SIFSIA Programme.
- In order to keep the WISDOM analysis "alive" and to make it effective for future planning, it is recommended to convert the current prototype into a structured information system including protocols for update and maintenance and a user-friendly interface for consultation and querying by non-technical users.
- Assess the economic accessibility of wood resources and the basic requirements of sustainable woodfuel production systems in the typical socio-economic and environmental contexts of Darfur. These parameters will be used to fine-tune the WISDOM analysis in order to determine the limits of the "management" option and to define with precision the target of alternative strategies aiming at reducing the demand and increasing the supply.
- Complement the biomass component with other essential natural resources thematic layers such as water, farming systems and livestock, poverty and vulnerability, in order to allow integrated cross-sectoral analyses
- Define a programme of natural resource monitoring and management in support of conflict resolution
- Define priority areas of intervention in a cross-sectoral analytical context and prepare a folder of project proposals for donors' consideration, including:
    - FES projects in rural and urban areas, giving priority to the areas showing marked deficit conditions.
    - Agro-forestry projects
    - Establishment of short rotation forest plantations
    - Fuel substitution programs
    - …
- Design capacity building actions aiming at strengthening institutional planning capacities at national and state levels and the full appropriation of the WISDOM experience by the relevant national and state government entities.
- In order to cope with the likely woodfuel crisis that will follow the separation of Sudan into two separate nations, it is highly recommended to carry out a WISDOM analysis over the remaining territory of North Sudan.

Medium term recommendations (< 5 years)

- Undertake capacity building programs for national and state-level institutions on planning tools (i.e. WISDOM and related tools) and sustainable resource management.
- Undertake Fuel Efficient Stove programs in rural and urban areas, giving priority to the areas showing marked deficit conditions.
- Undertake new planting and agro-forestry programs in the areas surrounding IDP camps (hopefully abandoned) and urban areas which were degraded and deforested due to woodfuel overexploitation.
- Introduce/promote participatory sustainable forest management and woodfuel production practices as source of livelihood in connection to returnees and resettlement programs.
- Undertake detailed state-level forest inventories with the scope of assessing the stock and the productivity of biomass resources.
- In collaboration with State Land Commissions, collect and organize/digitize Forest Reserves information in order to clarify and/or define access rights and governance issues.
- Prepare cross-sectoral resource management master plan for the whole of Darfur including forestry, livestock and agriculture, energy and poverty reduction, and other relevant planning sectors.

Long term recommendations (> 5 years)

- Prepare local operational management plans in the framework of the comprehensive master plan and in synergy with local stakeholders.
- Implement participatory resource management programs aiming at the creation of rural woodfuel markets, wherever feasible.

5.2.1 Initial portfolio of project ideas

WISDOM Darfur Information System

Scope:

to convert the current WISDOM Darfur "prototype" into a structured information system including protocols for update and maintenance of Supply and a user-friendly interface for consultation and querying by non-technical users;

Activities:

Following the procedures implemented for the creation of the WISDOM Darfur geodatabase, creation of the data handling protocols (input, processing, output) for the Supply, Demand and Integration modules to be used for system updating and maintenance.

Creation of a user-friendly interface enabling non-technical users to access, consult and query the WISDOM Information System and to produce a set of standard outputs for the selected areas of interest.

Tentative Budget:

BL	Items	Budget details	Tot Budget line (US$)
5013	Consultants	72000	72000
5542	Consultants – International BL		
	International IT Consultant (2 months)	24,000	
	International Web Application GeoNetwork (2 months)	12,000	
	International GIS Consultant (2 months)	12,000	
	International WISDOM Consultant (2 month)	24,000	
5543	Consultants – National		
	National IT Consultant (3 months)	9000	
	Webmaster (1 month)	3000	
5014	Contracts	5000	5000
5652	Contracts	5000	
5020	Support Staff	1500	1500
5652	Support staff (secretary, driver, temporary)	1500	
5021	Travel	31470	31470
5661	Travel costs		
5684	International Consultants (3 missions, 21 d.)	14985	
	(2 flights x 3360 = 6720	10080	
	21 days x 205 $/d + term	4905	
5685	National Consultants (6 days Darfur)	1500	
5692	Travel TSS	5000	5000
5698	Other		
5023	Training	0	0
5920	Training		
5024	Office supplies and expendables	3000	3000
6000	Expendables	3000	
	Office supplies		
5025	Non expendable equipment	10000	10000
6010	Computer & Software	10000	
5027	Technical Support Services	15000	15000
6111	Reporting		
6120	Technical Support Services	15000	
	Supervision		
5028	General operating expenses	7749	7749
6300	General operating expenses (5%)		
5029	Overhead	21154	21154
6118	Overhead (13%)	21154	

	Total		183873

Timetable:

Activity	month 1+2		month 2+3		month 3 to 5	
Demand module protocols						
Supply module protocols						
Integration module protocols						
User-friendly interface						
Presentation						
Missions		IT Cons				IT Cons+ W. Cons.

WISDOM communication strategy

Scope:

The objective of this activity will be to disseminate WISDOM Darfur's findings and to promote cross-sectoral policy formulation and sharing/strengthening the knowledge base for decision making.

Activities:

The activities below will be subsequent to the publication of the paper on WISDOM Darfur addressing policy makers and documenting the analytical process:

- Conduct state-level workshops to present WISDOM's findings, discuss the assumptions made and define follow-up actions aiming at the appropriation of the WISDOM tool by state-level institutions and agencies
- Promote cross-sectoral dialogue and the establishment of an inter-institutional / inter-agencies working group (WISDOM Team) at both technical and policy level through thematic workshops.
- Define priority areas of intervention in a cross-sectoral analytical context and prepare a folder of project proposals for donors' consideration.

Tentative Budget:

BL	Items	Budget details	Tot Budget line
5013	**Consultants**	**36000**	**36000**
5542	Consultants – International		
	International Communications Consultant	12000	
	International WISDOM Consultant (2months)	24000	
5543	Consultants – National		
	Comm. & Project Formulation Consultant (2 months)	6000	
5014	**Contracts**	**5000**	**5000**
5652	Contracts	5000	
5020	**Support Staff**	**1500**	**1500**
5652	Support staff (secretary, driver, temporary)	1500	
5021	**Travel**	**16770**	**16770**
5661	Travel costs		
5684	International Consultants (1 missions, 15 days)	6635	
	(1 flight x 3360	*3360*	
	15 days x 205 $/d + term	*3275*	
5685	National Consultants (21 days Darfur)	3500	
5692	Travel TSS	0	
5698	Other		
5023	**Training**	**30000**	**30000**
5920	3 Workshops	30000	
5024	**Office supplies and expendables**	**5000**	**5000**
6000	Consumables	5000	
	Office Furniture		
5025	**Non expendable equipment**	**0**	**0**
6010	Computer & Software	0	
5027	**Technical Support Services**	**15000**	**15000**
6111	Reporting		
6120	Technical Support Services (5days)	15000	
	Supervision		
5028	**General operating expenses**	**5764**	**5764**
6300	General operating expenses (5%)	5764	
5029	**Overhead**	**15735**	**15735**
6118	Overhead (13%)	15735	

	Total	**136769**	**136769**

Timetable:

Activity	month 1-2		month 2-4	
State-level workshops				
Thematic workshop				
Preparation of project proiposals				
Missions		**X**		

WISDOM analysis over North Sudan

Scope:

Scope of this project will be to analyze the demand for woodfuels and the supply potential in North Sudan through WISDOM. The division of Sudan in two separate nations will exacerbate the woodfuel deficit of North Sudan, traditionally depending on southern resources for woodfuel supplies. As in case of Darfur, the analysis will support the formulation of sound and locally tailored wood energy strategies.

Activities:

WISDOM activities will follow the phasing out of the on-going land cover mapping activities for North Sudan, which is estimated for completion by end 2011. In order to complete the analysis with minimum delay, it is proposed to carry out the analysis in two phases: a first phase over the central area (Kassala and Kordofan) and a second phase over the remaining eastern states.

Tentative Budget:

Lignes budg.	Items	Budget details	Tot Budget line
5013	**Consultants**	**84000**	**84000**
5542	Consultants – International		
	International GIS (3 months)	36000	
	International WISDOM Consultant (4 month)	48000	
5543	Consultants – National		
	National Supply Consultant (6 months)	18000	
	National Demamd Consultant (6 months)	18000	
5014	**Contracts**	**20000**	**20000**
5652	Contracts		
5020	**Support Staff**	**3000**	**3000**
5652	Support staff (secretary, driver, temporary)	3000	
5021	**Travel**	**48755**	**48755**
5661	Travel costs	48755	**48755**
5684	International Consultants (3 missions, 40 days)	18880	
	(3 flights x 3360 = 10080	*10080*	
	40 days x 205 $/d + term =)	*8800*	
5685	National Consultants (30 days)	6000	
5692	Travel TSS (1 mission, 7 days DSA)	4995	
	(1 flight = 3360 + 205*7+200Term.)		
5023	**Training**	**10000**	**10000**
5920	Training		
5024	**Office supplies and expendables**	**3000**	**3000**
6000	Expendables	3000	
	Office supplies		
5025	**Non expendable equipment**	**5000**	**5000**
6010	Computer & Software	5000	
5027	**Technical Support Services**	**33000**	**33000**
6111	Reporting	8000	8000
6120	Technical Support Service	25000	**25000**
	Supervision		
5028	**General operating expenses**		
6300	General operating expenses (5%)	11238	**11238**
5029	**Overhead**	**134969**	**34969**
6118	Overhead (13%)	34969	**34969**
	Total	**209207**	**209207**

Timetable:

Activity	month 1	month 2	month 3	month 4	month 5	month 6	month 7	month 8	month 9	month 10
Ph.1: Demand module										
Ph.1:Supply module										
Ph.1:Integration module										
Ph.2: Demand module										
Ph.2:Supply module										
Ph.2:Integration module										
Reporting										
Presentation										
Missions		**X**				**X**				**X**

References

Adam, A. A., 1998. Ecological aspects and dynamics of selected woody plant formations in Jebel Marra Mountains, Dar Fur-Sudan. M.Sc. Diss. TU-Dresden, Germany.

Bowen et al (1987) (estimates at 0.5 - 1.2 m3/yr/yr the recovery rate of the moderately degraded xerophilous woodland)

Bromwich B, Abuelgasim A. A., Abduljabbar A.F., F. Chege, J. Sweet, V. Tanner, and G. White. 2007. Darfur: Relief in a vulnerable environment. Teddington, UK: Tearfund.

Di Gregorio, A., and Jansen, L. J. M., 2000. Land Cover Classification System (LCCS): Classification Concepts and User Manual. Environment and Natural Resources Service, GCP/RAF/287/ITA Africover – East Africa Project and Soil Resources, Management and Conservation Service, FAO 2000.

Drigo R. 2005. WISDOM – East Africa. Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) Methodology. Spatial woodfuel production and consumption analysis of selected African countries. FAO Forestry Department - Wood Energy Working Paper. FAO. See: http://www.fao.org/docrep/009/j8227e/j8227e00.HTM

Drigo R. 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. Environment and Natural Resources Service (SDRN) and Forest Product Service (FOPP). Environment and Natural Resources Working Paper 27. FAO. ISBN 978-92-5-105710-0. http://www.fao.org/docrep/010/a1106e/a1106e00.htm

Drigo R. and F. Salbitano. 2008. WISDOM for Cities. Analysis of wood energy and urbanization aspects using WISDOM methodology. FAO Forestry Department. Urban forestry – Wood energy. FAO. (in English and French). English version: http://www.fao.org/docrep/010/i0152e/i0152e00.htm

Drigo R., 2008 (unpublished report). WISDOM Mozambique Final Report. Wood energy component of the Consolidation Phase of the Project “Integrated Assessment of Mozambican Forests”. AGRICONSULTING, for the Direcção Nacional de Terras e Florestas, Ministério de Agricultura, Moçambique

Drigo R., O. Masera, A. Ghilardi and M. Trossero. (In press). WISDOM methodology and applications. Wood Energy Programme. FAO.

Drigo R., O.R. Masera y M.A. Trossero. 2002. Woodfuel Integrated Supply/Demand Overview Mapping - WISDOM: a geographic representation of woodfuel priority areas. Unasylva 211, Vol. 53, FAO, 2002. Pp 36 – 40. (Published in English, French and Spanish). See: http://www.fao.org/docrep/005/y4450e/y4450e12.htm

Drigo R: 2009 (unpublished report). WISDOM Global – Phase I : Supply Module. Documentation Notes. Joint NRCE-FOIP activity. FAO.

FAO, 1980. Forest volume estimate and yield prediction, vol. 2- yield prediction, FAO forestry paper 22/2, Rome.

FAO, 1982. Fuelwood supply in developing countries. Forestry Paper 42:

FAO. 1987. Technical and economic aspects of using wood fuels in rural industries. Training in planning national programmes for wood-based energy. See: http://www.fao.org/docrep/006/AB780E/AB780E00.HTM

FAO. 2000. FRA 2000 Global Ecological Zoning (GEZ2000) <SEAsia_GEZ.shp>

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

FAO. 2004. WISDOM Senegal – Analysis of woodfuel production/consumption patterns in Senegal. Draft prepared by R. Drigo for the FAO Wood Energy Programme.

FAO. 2005a. Mapping global urban and rural population distribution. Prepared by M. Salvatore, F. Pozzi, E. Ataman, B. Huddleston and M. Bloise for FAO Poverty Mapping Project. [FAO] Environment and Natural Resources Working Paper, No. 24.

FAO. 2005b. i-WESTAT – Interactive Wood Energy Statistics. Update 2004. Prepared by R. Drigo and M.A. Trossero. See: http://www.fao.org/docrep/009/j6448e/j6448e00.HTM

FNC/FAO, 1996. National forest inventory for DarFur region- Khartoum, Sudan.

Forests National Corporation (FNC) and FAO. 1998. National Forest Inventory for the Sudan.

Galitsky, Christina, Ashok Gadgil, Mark Jacobs, and Yoo-Mi Lee. Fuel-Efficient Stoves for Darfur Camps of Internally Displaced Persons. Report of Field Trip to North and South Darfur, Nov 16 – Dec 17, 2005. Lawrence Berkeley National Laboratory, February 2006.
Abstract: An evaluation of cookstoves undertaken by LBNL to compare fuel efficient cookstoves with traditional three stone fires in the Darfur region, and gather data on food, cooking methods, fuel, and resource availability in IDP camps. The team conducted surveys of IDP households in North and South Darfur to better understand fuel and cooking needs, and investigate potential for fuel savings. The LBNL team tested stoves in laboratory and real life settings. The team concluded that metal stoves that are produced in a central location are preferable to mud-and-dung stoves, the production of which is difficult to control for quality.

GLOBCOVER - Products Description and Validation Report. Bicheron P. (Medias-France), Defourny P. (UCL), Brockmann C. (BC), Schouten L. (Infram), Vancutsem C. (UCL), Huc M. (Medias-France), Bontemps S. (UCL), Leroy M. (Medias-France), Achard F. (JRC), Herold M. (GOFC-GOLD), Ranera F. (ESA), Arino O. (ESA)

JRC-EC. 2003. The Global Land Cover Map for the Year 2000 (GLC 2000). European Commission Joint Research Centre. See: http://www-gem.jrc.it/glc2000/defaultglc2000.htm

Nelson, A. (2008) Estimated travel time to the nearest city of 50,000, or more people in year 2000. Global Environment Monitoring Unit - Joint Research Centre of the European Commission, Ispra Italy. Available at http://bioval.jrc.ec.europa.eu/products/gam/

Olsson K. 1985.University of Lund and University of Khartoum. 1985. Fuelwood demand and supply in the Umm Ruwaba/Er Rahad region in N. Kordofan, the Sudan. Remote Sensing Laboratory Department of Physical Geography, University of Lund

Omer Ibraheim Ahmed, Hussein Mahieldeen Hussein; Musa Adam Ismail and Suliman Adam Ahmed. 2009. Current Range Condition in West Darfur State. Study in some parts of Wadi Salih locality, University of Zalingei, Danish Refugee Council-Zalingei and UNHCR.

Openshaw, K. (1982) (applied an annual yield of woody biomass of 2.5 percent of the growing stock).

P. Khristova and A. W. Khalifa. 1993. Carbonization of some fast-growing species in Sudan. Forestry Department, University of Khartoum, People's Hall POB 6272, Khartoum, Sudan

UNEP. 2008. Destitution, distortion and deforestation. The impact of conflict on the timber and woodfuel trade in Darfur. Prepared by Margie Buchanan-Smith, Abuelgasim Abdalla Adam, Brendan Bromwich, Mohammed El Hafiz Ibrahim Dafalla,Abduljabbar Abdulla Fadul and Abdul Rahman Mohammed Tahir.

USAID. 2007. Fuel-efficient stove programs in IDP settings. Summary evaluation report Darfur, Sudan.

World Database on Protected Areas (WDPA) Annual Release 29 (web download version), February 29. 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. See : http://www.wdpa.org/AnnualRelease.aspx

Young H., Abdal Monium Osman, Ahmed Malik Abusin, Michael Asher and Omer Egemi. 2009. Livelihoods, Power and Choice: The vulnerability of the Northern Rizaygat, Darfur, Sudan. Feinstein International Center

ProAct. 2008. Assessing the effectiveness of fuel-efficient stove programming a Darfur-wide review. Programmatic review of fuel efficient stove projects in Darfur, conducted by a team from ProAct Network, including David Stone, Eugene Cole and Grant Wroe-Street. The review was contracted by CHF International on behalf of the Darfur Fuel Efficient Stove Working Group and coordination by FAO, UNEP, UNFPA and CHF.

Annex 1: Wisdom Darfur Supply Module data preparation and collection. Consultancy report

Mohamad Osman Mohamed El Hassan

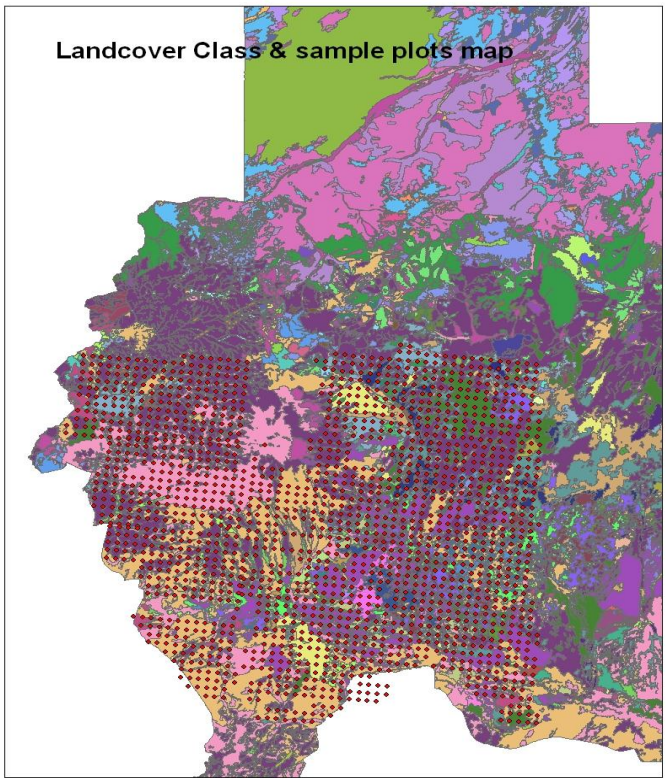
1. Introduction:

The report refers to the achieved of National Consultants for Supply in Darfur, the procedure for the detailed analysis of woodfuel, based on national forest inventory (NFI) data (1995) and field work verification (2010) in Darfur States. The complete sample plots map with basic attributes are used to calculate the supply map for the study area.:

1.1- Methodology

The basis of the NFI methodology is the measurement of fixed area plots on a systematic grid throughout the area to be inventoried. The plot locations were predetermined using the Geographic Information System and located in the field using the Global Positioning System ,grid (10 km by 10 km). The current positional accuracy of the GPS (15-20 meters) is such that for practical purposes the same area if not most of the same plot will be remeasured on a field work visit.

The use of the 5 degree orientation and the selection of a new starting point on each map sheet caused considerable extra effort to be expended in the processing of the data as the sampling grid did not coincide with the other map sheet



1.2- Basis data of NFI (trees file)

The field samples were 20 meters by 100 meters in size on a sampling grid of 10 kilometers by 10 kilometers. In each sample plot all wood vegetation with a root collar diameter of more than five centimeters and others variables were measured like the DRC-diameter 10 cm above ground level in cm, total tree height in meters and DBH (3-2cm), and they are some variables were estimated like the crown diameter and pole length.

All this variables are in the tree file, where we calculate the live-volume ,dead-volume ,timber-volume ,basal

area and crown area for individual trees and shrubs.

They are using the following equation to calculate them:

1- For all trees with a root collar diameter measurement that were not shrub species the total volume was calculated to be;
.5*(3.14159 *(root collar diameter/2)^2 * height)/10000

2- The shrub total volume was calculated using the equation
(.000406 * Crown diameter ^2 * Height).

Note: the programmed used to calculate stems and volumes for plot file as following:

```
SET TALK OFF
USE NFI_TREE
STORE 0 TO TDBH
STORE 0 TO TBA
STORE 0 TO TCROWN
STORE 0 TO TSHRUB
STORE 0 TO TSTEM
STORE 0 TO TMSTEM
STORE 0 TO THAS
STORE 1 TO TPLOT
DO WHILE TPLOT <1999
  COUNT TO TDBH FOR DBH>0 .AND. PLOT_NO = TPLOT
  SUM BA_DBH TO TBA FOR PLOT_NO = TPLOT
  SUM CROWN_AREA TO TCROWN FOR PLOT_NO = TPLOT
  SUM CROWN_SHUR TO TSHRUB FOR PLOT_NO = TPLOT
  COUNT TO TMSTEM FOR DBH >9.9 .AND. PLOT_NO = TPLOT
  COUNT TO TSTEM FOR PLOT_NO = TPLOT
  COUNT TO THAS FOR SPEC_CODE ='HAS'.AND. PLOT_NO = TPLOT
  USE NFI_SUMG
    REPLACE DBH_STEMS WITH TDBH*5 FOR PLOT_NO = TPLOT
    REPLACE BASAL_AREA WITH TBA*5 FOR PLOT_NO = TPLOT
    REPLACE CROWN_PERC WITH TCROWN/20 FOR PLOT_NO = TPLOT
    REPLACE CROWN_SHRB WITH TSHRUB/20 FOR PLOT_NO = TPLOT
    REPLACE STEMS_HA WITH TSTEM*5 FOR PLOT_NO = TPLOT
    REPLACE MERC_STEMS WITH TMSTEM*5 FOR PLOT_NO = TPLOT
    REPLACE HASHAB_HA WITH THAS*5 FOR PLOT_NO = TPLOT
  USE NFI_TREE
    TPLOT =TPLOT +1
ENDDO
CLOSE ALL
SET TALK ON
```

```
 SET TALK OFF
USE NFI_TREE
STORE 0 TO TSHRU
STORE 0 TO THVOL
STORE 0 TO TDVOL
STORE 0 TO TSVOL
STORE 0 TO TCHAR
STORE 1 TO TPLOT
DO WHILE TPLOT <1980
   SUM TOT_LIV_VO TO TLVOL FOR PLOT_NO = TPLOT
   SUM TOT_DEAD TO TDVOL FOR PLOT_NO = TPLOT
   SUM TIMBER TO TSVOL FOR PLOT_NO = TPLOT
   SUM TOT_SHRUB TO TSHRU FOR PLOT_NO = TPLOT
   SUM TOT_LIV_VO TO TCHAR FOR USE ='C' .AND. PLOT_NO = TPLOT
 USE NFI_SUMG
   REPLACE SHRUB WITH TSHRU*5 FOR PLOT_NO = TPLOT
   REPLACE LIVE_VOLHA WITH TLVOL*5 FOR PLOT_NO = TPLOT
   REPLACE DEAD_VOLHA WITH TDVOL*5 FOR PLOT_NO = TPLOT
   REPLACE STEM_VOLHA WITH TSVOL*5 FOR PLOT_NO = TPLOT
   REPLACE CHARCOAL WITH TCHAR*5 FOR PLOT_NO =TPLOT
USE NFI_TREE
    TPLOT =TPLOT +1
ENDDO
CLOSE ALL
SET TALK ON
```

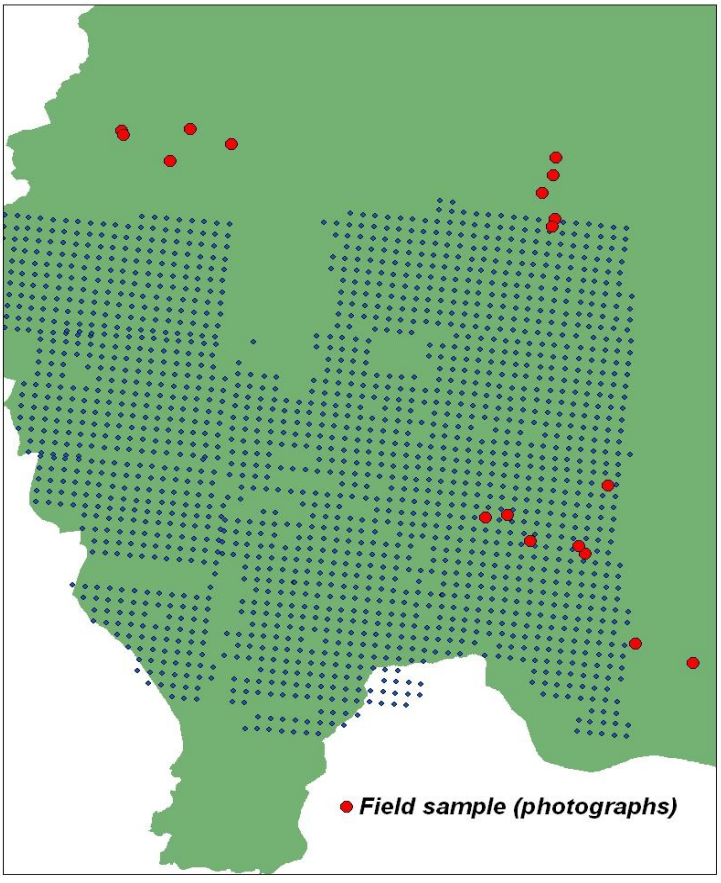
Observations were also made on :

Landover	T- trees, S- shrubs, G- grass, B- barren, W- water
land use	F- forestry, G- grazing, C- cultivated P- populated, U- unknown
land condition	N- no damage, E- eroded, F- subject to flooding, D- drifting due to wind, S-scouring due to wind, R- rill/sheet erosion due to water, G- active gully erosion due to water, P- pedestaled plants due to water or wind erosion
soil type	R- rock, S- sand (Goz), C- clay, L- loam, D- dune. A- river alluvium, SC sandy-clay
landform	W- Wadi, D- Dune, J- Jebel, K- Knorr N- No feature
history	CL- cleared for cultivation, PC-partially cut, CC-clear-cut
slope	percent
aspect	N, NE,E,SE,S,SW,W,NW or L for level
origin	NF- natural forest, P- plantation
years	No Cutting

The plot descriptions is base of summary file construction what we use for the final calculation of woody supply volume.

1.3- Field sample (photographs) for previous landcover

The field samples are a part of the land cover interpretation process. They help us to verify doubtful or unknown areas on the imagery and they provide a source of information that is unambiguous, there are 72 photos and 18 places cover the Darfur region



2- The volume calculation

The procedure is going on, volume estimates utilizing a 5 cm minimum top diameter. The following variables were used to predict volume:

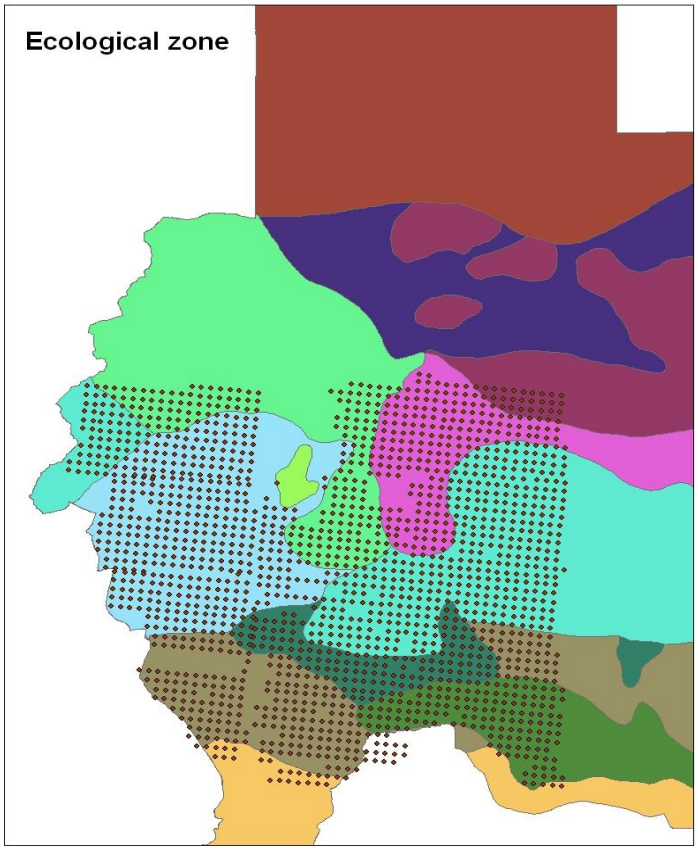
- Crown diameter in meters
- Trees file content the following parameter:
  - species
  - volume live/dead L-live, D-dead
  - DRC 5cm
  - height Meter
  - bole ht Meter
  - Crown diameter
  - cull percent

The following equations were use to predict volume:

1- For all trees with a root collar diameter measurement that were not shrub species the total volume was calculated to be;
5*(3.14159 *(root collar diameter/2)^2 * height)/10000.

2- The shrub total volume was calculated using the equation
(.000406 * Crown diameter ^2 * Height). The equation was developed by this consultant from previous sectioning work (Glen,1995).

The volume will be calculate according to ecological zone.



3- Stock and potential sustainable productivity:

The use of a wood supply model that incorporates the age class structure, volume age relationships, treatment responses, changing silvicultural inputs and harvest levels is the most common method of predicting the sustainable harvest level. An estimate of the past net growth can be obtained by calculating the average volume for the area and dividing this figure by the average age.

3.1 Tree age:

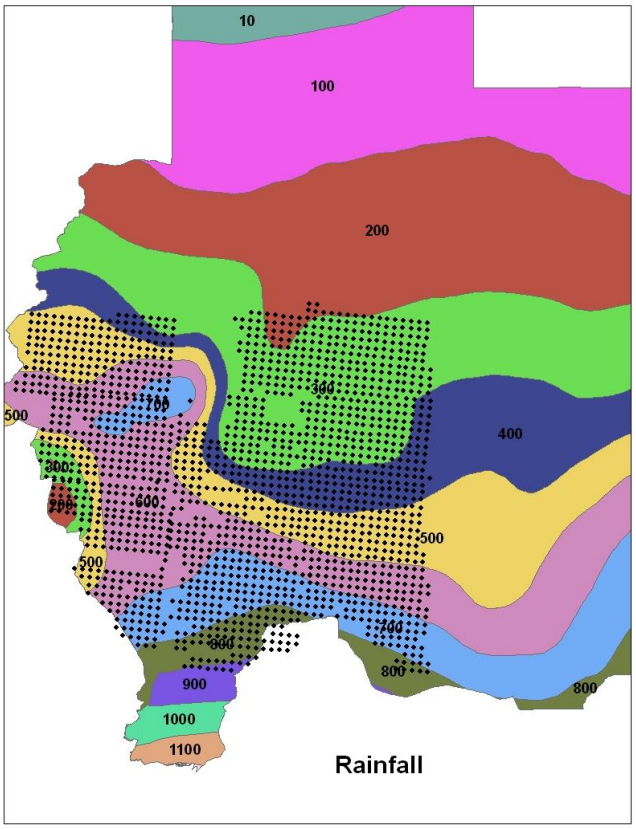
The determination of tree age is difficult for many species growing in the Sudan (Anonymous,1989a; Vink,1987; Vogt,1994). The proposed National Inventory methodology includes the estimation of stand age based on the field crews experience. This will provide one estimate, a second method is proposed based on rainfall and diameter using the equation

Age = QMDBH/(.728 + .0059*rainfall) Where DBH* is the diameter in centimeters at breast height of the average codominant tree, and rainfall is the average rainfall in millimeters (Anonymous,1989).

*Notes

Benessalah (1990) reported that a good relationship existed for Tahl (Acacia seyal Del. var. seyal Brenan) between DBH and DRC. The relationship gave an 'R' squared on .99.

The equation was DRC =1.15442*DBH.



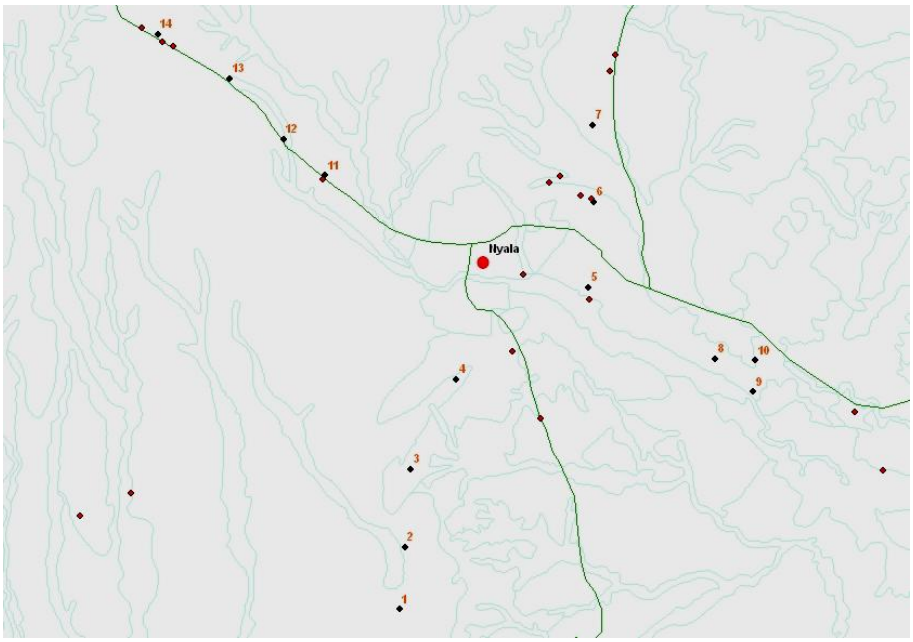
4- The field work:

South Darfur State

The fields work starting on 1/11/2010 for South Darfur(Nyala), on 2/11/2010 we have meeting with General director of Ministry of agriculture to select the secure area according to the proposed point. So we come to the conclusion, that were flow the constrictions of the security authority because, their is a big risk in this area while they take the 4w driver cars, our cars are from this type .Therefore our work done under critical condition . So It is collected according to accessibility of this area ,it is very difficult to navigate and follow the proposed point, put only the direction of it ,because of security situation there is a lot of check point, they can't allowed us to go away from the road , as you see in the map(1),

The proposed point in Muhajiriya area is not accessible, because of security situation.

Map(1)



The field sampling point have the following description :

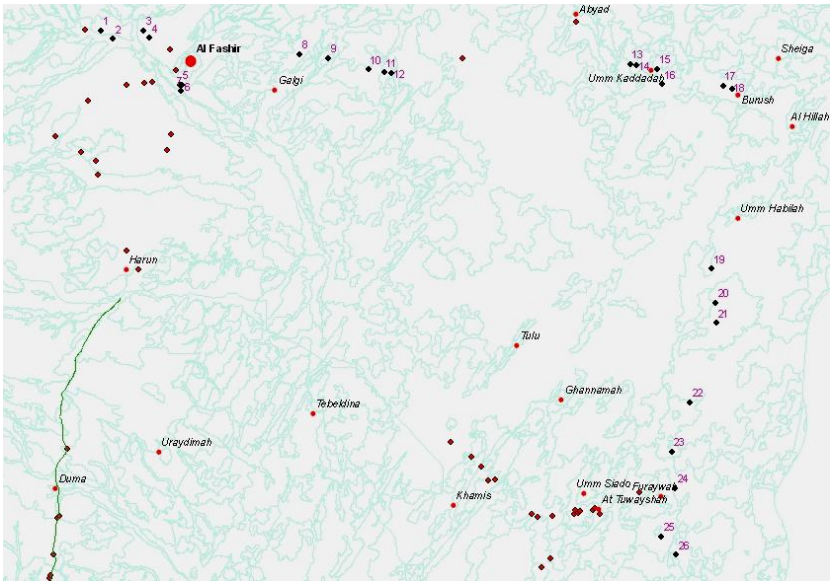
North	East	Cover Disc	Point no
1311740	264529	Agricultural area and very open trees	1
1315553	264873	Agricultural area sorghum crop	2
1320282	265224	Close grass and very open woody land tree type kiter	3
1325769	267995	Agricultural area sorghum crop very open grass and spars shrubs	4
1331367	276032	Very open shrubs and spars tree	5
1336570	276364	Agricultural area groundnut crop and spars trees	6
1341277	276285	Agricultural area sorghum crop very open grass and spars trees and shrubs	7
1327007	283747	Agricultural area sorghum crop very open grass and spars trees and shrubs	8
1325005	286046	Agricultural area millet and groundnut crop very open shrubs and spars trees	9
1326908	286217	Very open shrubs, grass and spars tree	10
1338203	260030	Agricultural area millet and spars shrubs	11
1340391	257476	Open to very open grass and very open woody shrub	12
1344102	254226	Open to very open trees and open grass	13
1346815	249815	Close to open grass and very open shrubs and spars tree	14

North Darfur State

The fields work starting on 9/11/2010 for North Darfur(El Fashir) ,the point were located in the field using the Global Positioning System and using the tracks to navigate it on a field , and visit the proposed point. The area are accessible better than southern Darfur state .We used comical car and the risk of lost and abstract is very low .We start from El Fashir and follow with Umm Kaddada from their to Ta Tuwayshah in south west the state ,southern of Ta Tuwayshah we found abstract from the military check point to go forward and they ordered us to go back in side the town ,so we start with east southern point (point 25,26)and we are continue to north of Ta Tuwayshah (point 19,-24) through Umm Habilah until Umm Kaddada again and over night . Next day we take the point (17,18) in direction UmBrush.

On 13/11/2010 we retain back to El Fashir in the road we take point(8-16) as you see in the map(2).

Map(2)



The field sampling point have the following locations and description :

North	East	Cover Disc	Point no
1507809	364603	Close grass(patch in agricultural area)	1
1513840	297146	Close grass and isolated sorghum field	2
1516554	306792	Agricultural area millet crop and very open grass	3
1514158	308632	Agricultural area millet crop and very open grass	4
1499482	318162	Agricultural area sorghum and different crop	5
1503162	384453	Agricultural area sorghum and millet crop and spars sh	6
1499191	488256	Agricultural area sorghum crop and very open grass	7
1509138	355760	Agricultural area millet crop and water melon	8
1507809	364603	Spars grass and spars tree	9
1504304	377192	Close to open grass and spars shrub	10
1499482	318162	Very open grass and spars tree	11
1503162	384453	Close grass and spars tree	12
1506028	459157	Close to open grass and spars tree	13
1505566	461204	Open grass and very open tree	14
1504491	467629	Rocky area with spars tree	15
1499614	469246	Close to open trees	16
1499191	488256	Close grass and spars tree	17
1498026	491038	Close grass	18
1441810	484640	Cclose grass and spars tree	19
1431103	485952	Close grass ,small sorghum field and spars tree	20
1424780	486108	Close grass	21
1399743	477961	Open tree and spars grass	22
1384468	472186	Very open grass and spars tree	23
1372826	473245	Open grass and very open tree	24
1357662	468849	Open and very open grass and spars tree	25
1352013	473669	Close grass spars shrubs and spars tree	26

Annex 2: Wisdom Darfur Demand Module. Consultancy report

Fath el Aleem Mohie el Deen

Wood Consumption in Darfur

1. General

The main objective of this report is the reviewal of existing data and information to arrive at an estimate of demand on wood fuel for all sectors including IDPs and other urban and rural households in Darfur.

The work involved a search of available existing literature on previous surveys and works. This included reports of FNC, National Energy Administration (NEA), FAO, UNEP, World Bank, USAID other organizations and relief agencies working in Darfur.

Generally consumption of forest products in Sudan started in 1960 when Jackson estimated the annual consumption of light construction poles as 0.5 – 2.14 million m3 and sawn timber as 0.076 million m3 while Saini (1964) estimated it as 0,153 million m3 (FAO and FNC,1995). The same source stated that Fenton(1990) based on Hunter's estimates estimated the national per-capita consumption of fuel-wood and sawn timber as 0.97 and 0.073 m3 respectively while the National Energy Administration gave estimates of 0.053 to 0.413 tones in the case of firewood and 0.077 to 0.141 tones in the case of charcoal.

The most recent forest products consumption survey was carried out by FAO and the National Forests Corporation (FNC) in 1995 under the project of Development Firewood Production for Energy.

The survey was the first of its kind covering all the Northern states. It gave consumption of wood by end use category by state. The survey used a multistage sampling design taking localities as primary units and villages in the rural areas and quarters in urban areas as secondary units (clusters) and systematic selection of households within each selected cluster with a random starting point. The survey results confirmed a number of findings of previous energy assessments which can be summarized as follows:

- All surveys and assessments stated that woody biomass constituted a percentage of more than 80% of the national energy budget.
- Household consumption of firewood was above 70%.
- Firewood consumption was higher in the rural areas while charcoal was higher in urban centers.
- Traditional commercial and industrial sectors like brick making, tobacco and fish smoking, bakeries, sawn timber and furniture making consume a small percentage of firewood consumption.
- Most of the consumed wood products come from outside the sustainably managed forest reserves.

Efforts are being made to obtain field data of the National Forest Products Consumption Survey of 1995 but this will take some time they are in the archives of the Central Bureau of Statistics. Obtaining such data will make it possible to estimate the actual pre-conflict consumption around the present IDPs camps locations.

Almost all reports of the organizations working in Darfur gave qualitative description of demand and consumption of wood in the region. Very few broad estimates of demand in some sectors are made based on limited interviews like the rise in demand in the sectors of building, construction due to the presence of large numbers of UN and AU forces, international relief organizations and highly paid nationals working with them.

1. Household Consumption:

Insecurity in the region far distances which need to be travelled to fetch wood and high competition of other consuming sectors created inflated prices of wood commodities including firewood needed for household domestic uses. Since the population of Darfur has logically decreased due to the migration of people outside the region to other places inside and outside Sudan and the scorching high prices of wood one will expect that the overall household consumption can never be higher than the pre-conflict consumption and hence the estimate of 1995 can still be conservative if taken for the present level of demand. The estimates of the IDPs demand which are rarely given by reports of organizations working in Darfur are rather unreliable as they are based on non-representative interviews and that fireplace measurements were never done. LBNL (2005) estimated the IDPs consumption of fuel-wood/day as 5 kg/ household. Annual consumption of a household will amount to 5*365 kg. For an average of 7 persons per household and with a conversion factor 720 kg./1

m^3 of air dry wood this gives a per capita consumption of 0.36 m^3 which is reasonable compared to the figure given by the national forest products consumption survey of 1995 (FNC/ FAO) considering the present scarcity and high prices. Sources of fuel wood are about 15-45 km from IDPs camps. Some IDPs take only two meals in a day and others take insufficiently cooked food.

The house hold per capita is kept as it is for the reasons stated above. According to the reports the maintenance, construction and furniture sectors have doubled or tripled and hence affected the per capita consumption for all sectors

3. Building and Construction:

High house rents caused by the high demand on housing after the coming of the joint peace keeping force staff and workers with the numerous relief organizations working in the area has triggered a very strong construction boom in the big towns of Darfur specially in Al Fasher where the UNAMID headquarters is located. The construction of the IDPs camps in the first years after the crisis began also required high quantities of building wood. Considerable amounts of timber are continuously needed for repairs and maintenance. This construction boom placed an increased demand on fuel wood for brick kilns and construction wood by 2 to 3 times (UNEP, 2008). Improved living standard of many residents who benefited from the increased employment opportunities with the organizations and high house rents also caused increased demand on sawn timber for construction and furniture making. UNEP estimated that 52 000 trees /year are needed for brick making. This is approximately equivalent to 5 000 m3 of wood taking an average tree of 15cm. diameter and 12m height.

However, FNC annual reports showed that bricks produced in the three states of Darfur are as shown in the table below in thousands of bricks:

State / Year	North Darfur	South Darfur	West Darfur	Total
2006	775 572	299 818	8 423,5	1083813.5
2007	684 782	129 630	125 661	940073
2008	-	9 156	10 299,3	19455.3
2009	1 200	-	8 260	9460
Total	1461554	438604	152643.8	2052801.8

Source: Extracted from FNC annual reports for the years 2006-2009

The table shows the big demand for bricks in the years 2006 and 2007 followed by a great drop in 2009.This can be explained by the construction boom which followed the coming of UNAMID forces and other organizations to the region and the decrease in demand afterwards. These figures show the quantities of bricks on which royalties were collected by FNC. It is believed by foresters in the region that the royalties collected by FNC might only be 75% of the bricks actually produced. Wood used in brick making industry in the three states during those years using a conversion factor of 0.486 m3 of air dry wood for one thousand bricks can be summarized as follows:

Year	Wood (m^3)
2006	702 311.148
2007	609 167.304
2008	12 607.0344
2009	6 130.08

Saw Mills and Furniture

	Nyala		El Fasher		El Geneina		Zalingei	
	Sawmills	**Carpentry Workshops**	**Sawmills**	**Carpentry Workshops**	**Sawmills**	**Carpentry Workshops**	**Sawmills**	**Carpentry Workshops**
Pre-conflict	10-13	NA	3	10	10	65	3	NA
2008	30	NA	15	30	17	120	21	17

Source: UNE, 2008

It can be seen from the table that the numbers of saw mills and carpentry shops have doubled or tripled and hence it can be assumed that furniture making might have increased in the same ratio.

4. Bakeries

It was also mentioned in several reports that the number of bakeries increased in all towns as well as in IDPs camps because of increase in displaced population and changing food habits due to changed living conditions in the camps and towns. No recent estimate of fuel wood consumption of bakeries was made but it can be estimated if it is possible to determine the number of bakeries or the total amount of flour used.

5. Fuel Efficient Stoves:

Reports showed that fuel efficient stoves (FES) or improved stoves are 30-50% more efficient than the traditional three stones fires. Introduction of FES started in the Sudan in the middle of the1970s to determine if their wide spread could have a significant impact on fuel wood consumption as the need for firewood puts great pressure on the environment, involves high expenditures and expose IDPs specially women and young girls who usually collect firewood to great risks. There are several types of FES which were developed and their efficiency tested. IDPs from Darfur accepted the improved mud stove (ITDG stove) introduced by CHF International. Many organizations are implementing FES programs in Darfur as listed below:

International Lifeline Fund

1220 N Street, NW Suite PH2

Washington, DC 20005

Christian Children's Fund

2821 Emerywood Parkway,

Action Against Hunger USA

247 West 37th Street, Suite #1201

New York, NY 10018

Food for the Hungry

1224 E. Washington Street Phoenix, AZ 85034-1102

Relief International

1575 Westwood Blvd #201

Los Angeles, CA 90024

Samaritan's Purse
P.O. Box 3000
Boone, NC, 28607 USA

Save the Children Fed. Inc
54 Wilton Road
Wilton, CT 06880

World Relief Consortium
Mark Smith
7 E Baltimore Street
Baltimore, MD 21202

World Vision
301 I Street, NE
Washington, DC 20002

Documents and References reviewed:

UNDP/World Bank, Energy Sector Management Assistance Program in Sudan.

IGADD, Household Energy in the IGADD countries Project Analysis

UNHCR, 2002, Cooking Options in Refugee Situations

UNEP, 2008, Destitution, Distortion and Deforestation The impact of conflict on the timber and wood fuel in Darfur

UNJLC, Cooking Fuel Options Help Guide

USAID, 2007, Fuel Efficient Stove Programs in IDPs Settings- Desk Study

Women's Commission for Refugee Women and Children, 2006, Finding Trees in the Desert. Fuel wood Collection and alternatives in Darfur

FNC/FAO, 1995, Forest Products Consumption Survey, Final Report

FNC, 2006- 2009, Annual Reports

Annex 3: WISDOM meetings - participants

Participants to the WISDOM Darfur presentation meeting held at FAO Conference room, Khartoum, on 10th December 2010.

The meeting was opened by Marc Abdala, Senior Emergency and Rehabilitation Coordinator, FAO.

Name	Organization	Title	Email	Telephone (+249)
Daniel Gonzalez Levassor	EU Delegation	Envionment/ Food Security	Daniel.gonzalez-levasson@ec.europa.eu	
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R. Neil Munro	GAF/Darfur Land Commission	Team Leader	Neil.munro@dial.pipex.com	915516564
Ernst Loeffler	GAF/Darfur Land Commission	Geom.		
Autje Kupper	GAF/Darfur Land Commission	Project Director	Autje.Kupper@gaf.de	
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Tayfoor Osman	USAID	F. security specialist	osman@usaid.gov	912326804
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Rudi Drigo	FAO Consultant	WISDOM analysis	rudi.drigo@fao.org	

A meeting on WISDOM Darfur was held at the National Forests Corporation on December 2nd, 2010, in the framework of the National Forest Programme Workshop, was attended by 23 participants, among which the following:

Name	Organization	Unit
Mamoun Gasim Musa	**FNC**	**Investment Sector**
Salah Yousif	**FNC**	**Forest Inventory Section**
Sawsan Abdalla	**FNC**	**Afforestation Section**
Dr. Falat Daffalla	**University of Upper Nile State**	**Senior Lecturer**
Ibrahim Rahamtalla	**FNC**	**Gum Arabic Marketinf and Production Revitalization Project**
Dr. Yousif Ahmed	**FNC**	**Training Section**
Mutasim Mohammed	**FNC**	**Sahel Training Center**
Samia Bakhiet	**FNC**	**GIS Section**
Johan Lejeune	**FAO**	**National Forest Programme Facility**