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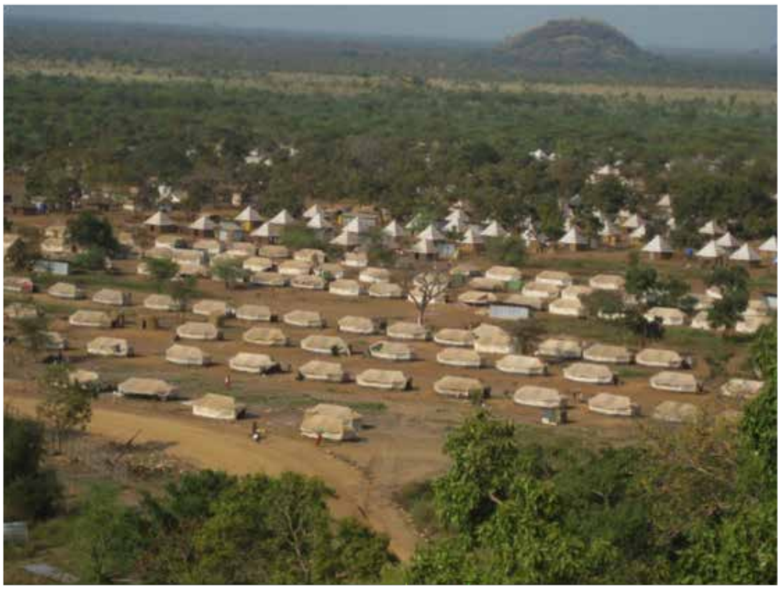
ASSESSING WOODFUEL SUPPLY AND DEMAND IN DISPLACEMENT SETTINGS



A technical handbook

ASSESSING WOODFUEL SUPPLY AND DEMAND IN DISPLACEMENT SETTINGS

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Food and Agriculture Organization of the United Nations and
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Foreword

Displacement caused by conflict and natural hazards has increased dramatically in recent years with many people seeking refuge in camps and improvised settlements within their countries of origin and across international borders in host countries. UNHCR estimates that at the end of 2015, the number of people forcibly displaced as result of persecution, conflict, generalised violence or human rights violations had risen to a staggering 65.3 million, compared to 51.2 million just two years earlier and 37.5 million a decade ago.

Forced displacement impacts most directly upon the people uprooted from their homes but also on the communities that receive and host them. The arrival of large numbers of refugees and internally-displaced people often creates critical challenges in terms of shelter, health, food security, nutrition, education, environment and energy, as well as serious protection concerns, including the increased risk of sexual and gender-based violence.

Through advocacy efforts, such as the UN Secretary-General's Sustainable Energy for All (SE4ALL) initiative, and the adoption last year of Global Goal 7 within the framework of the 2030 Agenda for Sustainable Development, access to safe and reliable access to energy for all is now recognized as essential for sustainable development. Despite this increased global momentum, however, access to energy is often overlooked in emergency response, due to a lack of funding, technical specialist capacity and reliable data. Safe access to fuel and energy – for cooking, lighting and other essential uses – remains a significant gap in humanitarian interventions.

Without the means to cook food, people face dire consequences relating to food security and nutrition. Environmental degradation around camps can also occur rapidly and may become irreversible, with significant implications for communities dependent on natural resources for their livelihoods and well-being. A recent study by the Moving Energy Initiative estimates that 64 700 acres of forest are burned each year to meet the energy needs of displaced families. One of the main drivers of degradation is demand for wood as fuel and to produce charcoal, which are used by both displaced and local populations.

Where forests have been depleted, the increasing scarcity of wood for cooking fuel may exacerbate tensions and conflict between communities who compete for access to the same natural resources. Women are particularly vulnerable to harassment, assault and other forms of violence when walking long distances to collect fuelwood. While gathering wood for fuel, women are not engaged in income generating activities, and the children who help them are out of school. They are also at risk of exposure to respiratory illnesses when cooking on traditional three-stone fires. The lack of safe access to fuel and energy thus has broad repercussions for the protection, health, nutrition and even livelihoods and education of refugees and other displaced people and the communities where they are living.

The Food and Agriculture Organization of the United Nations (FAO) and the Office of the United Nations High Commissioner for Refugees (UNHCR) are members of the inter-agency Safe Access to Fuel and Energy (SAFE) Humanitarian Working Group which seeks to facilitate a more coordinated, predictable, timely, and effective response to the fuel and energy needs of crisis-affected populations. The initiative employs multi-disciplinary approaches that build resilience by addressing environmental, food security and nutrition, health and gender-related challenges.

UNHCR launched a five-year Global Strategy for Safe Access to Fuel and Energy in 2014, which guides the organization's work in this crucial area. FAO and other partners enriched the Global Strategy by contributing their expertise and knowledge. UNHCR is ensuring real impact in the field through development of context-specific country-level SAFE strategies. Since 2014, UNHCR operations in ten countries have adopted national SAFE strategies, with more to follow in 2016 and beyond.

This Technical Handbook contributes to implementation of the UNHCR's Global Strategy for SAFE by building a better understanding of the interlinked dynamics of wood biomass supply and demand in displacement settings, both in acute emergencies and protracted crises. Use of the Handbook can help to establish a baseline for planning, monitoring and evaluating interventions to enhance energy access, reduce risks of land degradation and overexploitation of natural resources, contribute to enhanced protection, and build the resilience of livelihoods in and around displacement camps. The Handbook also provides a clear and concise methodology for assessing and mapping the gap between demand for cooking fuel inside camps and settlements and the supply of wood fuel from surrounding areas, and it can help field-based actors and decision-makers take appropriate actions and find solutions that build the resilience of affected populations.

Through the Technical Handbook and its broader partnership with UNHCR, FAO is realizing its Strategic Objective 5 "Increase the Resilience of Livelihoods to Threats and Crises". Working with FAO, in turn, enables UNHCR to take forward Strategic Objective 5 in the Global Strategy, which promotes community-managed, multi-purpose plantations and agroforestry activities as resource banks, both in and around settlements/camps, by providing enhanced tools to access data for monitoring and decision-making.

As UNHCR rolls out SAFE activities in the field, FAO will continue to provide support through normative work, such as this Technical Handbook, as well as by directly supporting refugees and internally displaced persons on the ground in collaboration with UNHCR.

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Acronyms

ARR	Afforestation/Reforestation/Restoration
DBH	Diameter at Breast Height
DFID	Department for International Development
DHS	Demographic and Health Surveys
FAO	Food and Agriculture Organization of the United Nations
FOSS	Free and Open Source Software
FRA	Forest Resources Assessment
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GLCN	Global Land Cover Network
GPS	Global Positioning System
IDPs	Internally Displaced Persons
IEA	International Energy Agency
IMAD	Iteratively Multivariate Alteration Detection
LCCS	Land Cover Classification System
LSMS	Living Standards Measurement Study
MICS3	Multiple Indicator Cluster Surveys
OFDA	Office of Foreign Disaster Assistance
PRA	Participatory Rural Appraisal
RRA	Rapid Rural Appraisal
SAFE	Safe Access to Fuel and Energy
UNHCR	United Nations High Commissioner for Refugees
USAID	United States Agency for International Development
WFP	World Food Programme
WHO	World Health Organization
WISDOM	Woodfuel Integrated Supply/Demand Overview Mapping

Executive summary

The objective of this manual is to present a methodology for assessing woodfuel supply and demand in displacement settings. It uses a multi-sectoral approach to address the energy needs and associated health, safety, protection, nutrition and livelihood challenges of displaced people.

The first part of the manual presents the methodology for assessing demand for woodfuel, which is structured around four sequential steps. Each step provides explanations and the means to collect data and information, based on the specific targeted area and population.

Part I. Demand

Step 1: Determine the population and social units

The staff identify different social units and carry out quantitative surveys and qualitative interviews at the camp/community level. This includes in-depth interviews with key informants such as camp managers, NGO staff, community mobilizers, community leaders and other relevant respondents.

Step 2: Assess energy consumption

They assess energy consumption with a particular focus on woodfuel (fuelwood and charcoal) by determining the types and quantity of fuels used for cooking per social unit in a given time period (e.g. day, week or month) and the particular circumstances under which they are obtained.

Step 3: Screen technologies and assess local practices for cooking

Following an initial identification of the main cooking systems used in the targeted displaced and host communities, the staff screen the technologies and assess local cooking practices. The screening and assessment involves a multi-sectoral approach, which considers several variables such as the availability, accessibility and affordability of alternative energy sources. The baseline screening provides entry points for conducting a feasibility assessment of locally appropriate and fuel-efficient cooking systems.

Step 4: Assess the multi-sectoral challenges to access and use of woodfuel

They analyse the multi-sectoral challenges in accessing and using woodfuel for displaced households, in particular for female household members, and link them to the choice and use of specific fuels and cooking technologies. A thorough analysis should take into account protection aspects, environmental/forest degradation, nutrition, health and safety for the specific targeted area and population.

The second part of the manual describes the methodology for assessing the woodfuel supply of the targeted area, based on a combination of field measurements and temporal change analysis of satellite imagery for the different land cover classes that provide woody biomass. This section is also structured around four sequential steps, as described below.

Part II. Supply

Step 1: Define the sources of woodfuel

The definition of woodfuel sources should include closed and open forest land, as well as dedicated energy plantations, shrubland, savanna and agricultural land. Short interviews with local stakeholders should enable identification of the woody biomass resources for the area of study. Information collected during this step can be combined with data from the interviews conducted during the woodfuel demand assessment to determine which resources to target.

Step 2: Map the distribution of woodfuel resources

It is important to acquire satellite imagery of the defined targeted area with an adequate resolution to capture vegetation characteristics and changes. Satellite or aerial images are the primary source of information for the development of spatial representations. To allow for changes in woody biomass resources, at least two dates should be investigated with a sufficient time lapse between points. This step is carried out in two stages: (i) legend creation and (ii) image processing for land cover area change assessment.

Step 3: Estimate stocks

Above-ground woody biomass stocks can be estimated from direct measurements on the ground, with an appropriate sampling design and tree and shrub measurement protocol. These estimations are then combined with the mapped resources to create comprehensive stock mapping. This step is carried out in three stages: (i) sampling and plot design; (ii) measurement protocol; and (iii) generation of spatial biomass data distribution. The output of the field measurements is a database containing plot descriptors with all associated tree and shrub measurements.

Step 4: Assess stock changes

This last step consists of measuring changes in the growing stock at two points in time by assigning local biomass estimates to land cover classes, or by assessing wood biomass changes through field inventory. Two alternative methods are presented: the Stock-difference method measures stocks at two points in time to assess stock changes, and the Gain-loss method includes all processes that bring about changes.

The manual also presents a methodology for integrating demand and supply assessments into informed decision making for monitoring, evaluating and planning purposes in the targeted area.

Finally, the manual concludes with a case study on the use of these methodologies in one refugee camp in Ethiopia.

1. Background

Energy is considered a crucial component of the physical capital needed to ensure sustainable livelihoods (DFID, 1999), but is often overlooked in humanitarian response interventions in acute emergencies and protracted crises. Energy is needed to cook, process and preserve food, conserve vaccines for human and animal disease prevention, and irrigate crops. Its presence is vital to numerous purposes essential to the immediate needs of affected people, speeding up recovery and building resilience to future shock events.

In acute emergencies and protracted crises, the provision of sustainably sourced cooking fuel coupled with appropriate, efficient and clean cooking technologies, can function as a life-saving intervention.[1] Fuel-related interventions are crucial from a food security and an environmental perspective. Regardless of whether food is provided in the form of rations or produced locally, there is a need for a safe, stable and sustainable supply of energy for cooking and heating.

About 2.8 billion people in developing countries rely on biomass fuels (e.g. fuelwood, charcoal and animal dung) to meet their energy needs for cooking food (IEA, 2010). Fuelwood plays a vital role in ensuring the food security of millions of people and its consumption must be better understood in order to address resource shortages and forest decline (MacDonald, Adamowicz and Luckert, 2001). However, the supply and use of fuelwood are often embedded in complex systems that include external factors of a non-forestry nature, which influence the capacity to provide forestry-based solutions (FAO 1983). Natural resources including fuelwood must therefore be carefully managed and monitored to meet current demands and ensure sustainability (Warner, 2000).

In densely populated areas such as displacement settings, ensuring access to natural resources including woodfuel can be highly challenging. During protracted crises, camps for refugees and internally displaced persons (IDPs) are often established in locations where natural resources are already scarce, and where limited access to dwindling resources poses the risk of increased food insecurity and social conflicts.

Environmental impacts resulting from the unsustainable extraction, collection and/or use of woodfuels can be long-lasting and cause damage. Sustainable natural resource management (e.g. community-based forest management) can reduce these impacts and ensure a sustainable fuel supply in tandem with reforestation. Fuelwood can be supplied through a variety of tree and forest systems, such as mixed forest plantations, or through integrated food energy systems that produce both food and energy, such as agro-forestry or multiple cropping systems (FAO, 2010). Interventions on the demand side are also necessary to ensure a significant reduction in the unsustainable exploitation of forest resources, decreased expenditure on fuel, and reduced exposure to risk for collectors of fuelwood and other challenges faced by crisis-affected households.

1 See, for example, http://practicalaction.org/our-work/stovesandfuel-darfur.

Assessment of the sustainability of fuelwood extraction is challenging (Arnold, Köhlin and Persson, 2006) and is further complicated by the limited availability of basic data such as fuelwood stocks, harvesting methods, population census, energy consumption and energy needs. To be effective, surveys must reflect interrelationships within the surrounding systems and be carefully designed to elicit the appropriate level of detail (FAO, 1983). The sustainability of fuelwood extraction can be evaluated by assessing: (i) the standing woody biomass available for use as fuel (woodfuel supply), (ii) consumption over a given period of time (using woodfuel consumption as a proxy for woodfuel demand), and (iii) the interrelationships and gaps between demand and supply. This evaluation method determines whether the rate at which wood is harvested outpaces the natural or managed rate of woody re-growth in nearby areas and can supply options for improving energy use.

To address the need for approaches that help identify critical areas, and to focus resources and/or actions related to fuelwood extraction in places that face the most acute problems, FAO in collaboration with the Institute of Ecology of the National University of Mexico has developed the Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) methodology.[2] WISDOM is a spatially explicit tool for highlighting and determining fuelwood priority areas or fuelwood hot spots at national or sub-national scale (Masera et al., 2006). This manual builds upon WISDOM by assessing woodfuel supply and demand at the level of displacement camps through the collection of primary data in the field. Advances in data acquisition and analysis offer new possibilities to cope with the methodological challenges encountered when using traditional approaches. Such new and necessary approaches are more inclusive of other measurable parameters and are integrative, multi-scalar and multi-temporal.

The methodological approach proposed in this manual, while inspired by WISDOM, focuses more on supporting local resource management and planning for woodfuel supply at smaller scales. It is particularly relevant for assessments in and around emergency or protracted displacement camps. The methodology assesses needs by considering demand and supply, and takes into account the difficulties in identifying sustainable harvesting practices without ground-level field surveys.

2 www.wisdomprojects.net/global/

2. Scope and objectives of the manual

The first objective of this manual is to promote a better understanding of the dynamics of woody biomass extraction and consumption in emergency and protracted refugee and IDP camps. This requires an assessment of the available forest and wood resources and an analysis of demand, based on population evolution over time and humanitarian needs in the targeted area. Identification of the different social units and the potential woodfuel resources in and around refugee/IDP camps is a necessary step in guiding the sustainable management and use of forest and wood resources.

The second objective is to allow technicians and staff involved in the management of natural resources, and the protection of populations in and around displacement camp settings, to assess woodfuel supply and demand through the use of the guidelines provided in this manual. The proposed methodology presents global data sources that are applicable in any country, but which are tailored for data collection under the specific conditions and settings found in and around displacement camps. This methodology relies on field inventory data, high-resolution satellite images, and relevant technical and socio-economic data for a thorough, in-depth assessment of woodfuel supply and demand.

The proposed methodology (see Figure 1) consists of four integrated components: the present manual; free open source software for satellite image processing; an Excel-based toolbox developed to support the collection and analysis of field data; and, where possible, in-country support to help ensure the adoptability and adaptability of the proposed approach.

Figure 1: Four components to support the assessment of woodfuel supply and demand

3. Methodology and outputs

The results from the woodfuel demand and supply assessment should be used as entry points to identify appropriate and fuel-efficient cooking systems for the sustainable management of energy demand and supply in emergencies and protracted crises. The methodology also provides a baseline for monitoring, evaluating and planning interventions to enhance energy access, reduce risks of land degradation and overexploitation of natural resources, and build the resilience of livelihoods in and around displacement camps.

In terms of the local context, it is important to define the area of study and, within this area, the relevant local specific data. Some of these data may already be available and some may need to be collected through the field survey.

4. Assessing woodfuel demand

Assessing demand for woodfuel should start with the end users for energy. Displaced and local households often use a variety of fuels either purchased or collected in the area surrounding the camps, depending on availability. Households may also employ a variety of cooking technologies that differ in terms of energy efficiency, harmful smoke and particle emissions, safety, fuel type, size, materials and cost. The combinations of fuel types and technologies are highly context-specific and require data collection in the field to identify the particular needs, challenges and solutions.

Short and structured questionnaires for household respondents can be used to gather information on access, availability and consumption of fuels, and can also be used to establish a baseline. The assessment of woodfuel demand is carried out by analysing technical and socio-economic data collected in the field using methods such as brief questionnaires, focus group discussions, semi-structured interviews with key informants, observations of cooking practices and other participatory rural appraisal (PRA) techniques.

4.1 Research design and sampling strategy

Prior to conducting fieldwork, an appropriate research design and sampling strategy should be elaborated, taking into account the following:

- consideration of available data and past, present and ongoing multi-purpose socio-economic studies;
- approach (e.g. quantitative, qualitative, mixed methods);
- the elaboration of field methods and interview guides (e.g. questionnaire surveys, semi-structured interviews, PRA);
- selection of an appropriate sampling size to ensure a level of statistical accuracy commensurate with time and resource constraints;
- preliminary selection of respondents (e.g. household members, key informants, social groups);
- logistics and other practical arrangements;
- a feasible work plan.

Quantitative survey questionnaires usually select a sample population, as the total camp population is too large to cover given the timeframe and available resources.

The use of structured questionnaires to collect information from households can provide detailed quantitative socio-economic data such as the size of the household, sources of fuel for cooking, consumption of fuel, expenditure on fuel, cooking technologies and cooking practices. The use of questionnaires can be supplemented by qualitative methods such as semi-structured interviews and PRA techniques, which include focus group discussions and mapping exercises. These methods can elicit more in-depth information and allow respondents greater flexibility in their responses.

Semi-structured interviews are recommended for gathering in-depth information. These types of interviews do not follow a rigid, quantitative format and allow respondents to discuss topics of interest to them and provide more detail about specific issues (Mikkelsen, 2005). Semi-structured interviews can be used for key informants, household members or in a group setting. Groups can consist of either homogenous or mixed groups of people in a community, as long as group composition is considered in the subsequent analysis.

Participatory rural appraisal comprises a set of approaches and methods for understanding and assessing the local context and livelihoods of people and social groups within a particular geographical area (Chambers, 2008), such as a camp for displaced people and/or a host community. PRA is usually implemented by following three main steps: (i) selection of a community or village; (ii) a preliminary visit; and (iii) actual application of PRA (Selener, Endara and Carvajal, 1999). Common PRA techniques include the development of Venn diagrams, seasonal calendars, time use calendars, village/camp timelines and wealth rankings. All these approaches can generate useful qualitative data on fuel demand and related challenges.

The following sections present four steps to assess woodfuel demand in displacement contexts.

4.2 Step 1: Determine the population and social units

The first step in the demand assessment is to determine the size and characteristics of the population, as well as the institutions and other social units that provide services to the population. The studied sample should ideally allow one to make valid conclusions about the population. However, before selecting the sample, it is important to define the population and include a description of the social units to be assessed. Therefore, the size of the sample of households and other social units depends on a number of parameters, such as the distribution and number of households, number of variables of interest, degree of homogeneity of the variables under consideration and acceptable error.

A random selection of "n" units of the population should be selected using a method that ensures that all possible units have the same probability of selection. A minimum simple size of 30 units can be considered as the lower bound to estimate the mean of quantitative variables over large datasets. The final decision on sample size will also depend on the timeframe and the availability of monetary and human resources for conducting the field survey.

Existing data on the population and social units can be obtained from the various databases provided in Annex 1. However, in order to obtain more detailed and precise data, quantitative surveys and interviews should be carried out at the camp/community level. This will necessitate in-depth interviews with key informants such as camp managers, NGO staff, community mobilizers, community leaders and other relevant respondents.

The following indicators are used to assess population trends:

- total current population and fluctuations over time;
- social units: the number and average size of households, schools, clinics, administrative centres and other categories;
- demography: disaggregation of data according to gender and age;
- social groups: countries of origin and/or specific ethnic groups.

Demographic data from refugee camps can be found on the UNHCR Statistical Online Population Database (see Annex 1). The database provides figures on the total population in all camps in a country, disaggregated by gender and age. The Internal Displacement Monitoring Centre managed by the Norwegian Refugee Council provides global monitoring data of IDPs in sub-Saharan Africa (20 countries), the Americas (four countries), Europe and Central Asia (12 countries and territories), Middle East and North Africa (8 countries), and South and South-East Asia (13 countries). More detailed data can be obtained from the UNHCR Emergencies database for specific regions and hotspots in sub-Saharan Africa (e.g. the Sahel, Horn of Africa, South Sudan, Central African Republic and Nigeria) and the Middle East (the Syria Emergency). UNHCR country websites also provide useful demographic statistics and data. Operational and country updates[3] may provide information on the number and types of institutions[4] found in specific camps or sub-national areas.

4.3 Step 2: Assess energy consumption

A number of factors influence the energy demand for cooking and other basic needs in camps for displaced people. The amount of woodfuel (fuelwood or charcoal) used for cooking – using inefficient cooking technologies and practices – ranges from between 0.7 kg to 3 kg per person per day (Gunning, 2014). The precise quantity and type of woodfuel depends on several site-specific factors, including the availability and quality of wood, climate, type and quantity of food cooked, stove efficiency and cooking practices.

Field data on the type, source and quantity of fuel can be obtained through a combination of: (i) rapid, structured and quantitative questionnaires with household respondents; (ii) focus group discussions (disaggregated by gender) with household members; and (iii) semi-structured interviews with key informants including camp managers, community mobilizers, community leaders and stove producers.

A range of PRA tools can be used to map the location and distance of fuel sources, the challenges faced by fuelwood collectors and characteristics of particular cooking technologies, including information on their respective advantages and disadvantages.

3 See www.unhcr.org/pages/49e483986.html.
4 See, for example, www.unhcr.org/52e6664e8.html.

Interviews conducted with those responsible for cooking at the institutional level can provide key information on the technologies used and the amount of fuelwood needed to cook meals for schools, clinics and other institutions.

Availability, accessibility and affordability of alternative energy sources (e.g. biogas, kerosene, liquefied petroleum gas (LPG), electricity, liquid biofuels) are also relevant factors that influence woodfuel demand among the targeted populations. In some cases, other sources of available energy can be more competitive in terms of economic efficiency and flexibility of use and storage. By determining the type and quantity of fuels used for cooking per social unit over a given time period (e.g. day, week or month) and the circumstances under which they are obtained, it is possible to calculate the amount of energy consumed per social unit.

Woodfuel properties

When assessing woodfuel consumption, it is important to take into consideration the chemical and physical proprieties of the woody biomass. The most relevant properties are moisture content, energy content, mass, volume and density, as well as shape and particle size and total ash. Woodfuel can be measured by either weight or volume. One advantage of measurement by volume is that the difference between air-dried wood and wet wood is minimal. Conversely, the weight of wood is highly dependent on moisture content. However, weight may be a more convenient measure if the moisture content is determined and taken into account. The quickest and easiest way to assess the weight of a bundle of wood is to use a scale.

The moisture content in fuelwood can vary considerably depending on the atmospheric ambient conditions (mainly temperature, wind and humidity), the time of harvesting and the conditions of storage. Moisture content greatly influences the energy content of fuelwood. Therefore, it is important to ascertain the moisture content, if weight is used as a measure for assessing woodfuel consumption and efficiency during the cooking and heating processes.

In most practical applications, the energy content of woodfuel can be conveniently described by the low heating value (LHV), which is the heat effectively obtainable from one unit of fuel. Preferably, the LHV should be expressed in joules (or any of its multiples) per original unit, for example, gigajoule/tonne (GJ/t) or gigajoule/cubic metre (GJ/m^3).

By converting fuel consumption into units of energy, it is possible to compare woodfuel consumption with consumption of other types of energy. A quantitative estimate of cooking energy demand is required to evaluate the potential for alternative fuel sources and new cooking technologies.

4.4 Step 3: Screen technologies and assess local practices for cooking

The screening of technologies and assessment of local cooking practices should be carried out after an initial determination of the main cooking systems used in the refugee and host communities. The screening and assessment involves a multi-faceted approach, which considers several variables specific to the local context (see Step 4). The baseline screening provides entry points for conducting a feasibility assessment of locally appropriate and fuel-efficient cooking systems.

The availability of improved cooking technologies can be assessed by conducting a market survey, while interviews with local artisans and households in host communities can help to ascertain demand to support the production of stoves appropriate for end users under local conditions. The selection of sustainable cooking technologies should take into account the level of energy access, the main foods that are cooked, the potential for communal cooking, the use of fuel-saving cooking practices, and the types and number of pots and utensils used by households. Using the stove's efficiency rating it is possible to estimate the reduction in fuel consumption when new stoves replace existing or traditional stoves (WFP, 2012). If the efficiency rating is unknown, it can be tested using three internationally agreed protocols that measure efficiency, emissions and safety:

- the water boiling test;
- the controlled cooking test;
- the kitchen performance test.

Households and institutions may employ several kinds of cooking methods and technologies. These influence both current and future demand for woodfuel and are also key factors in the success or failure of fuel-related interventions to improve the well-being of displaced populations. The following information should be collected at field level:

- cooking technologies currently used, such as three-stone fires, mud stoves, ceramic stoves and metal stoves;
- types and total number of fuel-efficient household stoves distributed, disaggregated by type of stove and fuel;
- types and total number of fuel-efficient institutional stoves distributed, disaggregated by type of stove and fuel;
- proportion of traditional and improved stoves distributed in accordance with population trends and social units;
- energy efficiency of various fuel/stove combinations;
- cooking practices such as communal cooking and fuel-saving practices;
- types of food prepared and cooked;
- utensils and cooking equipment used;
- types of alternative fuels, such as briquettes, biogas, ethanol, kerosene, LPG and electricity.

The cooking technologies found at country, sub-national and, where available, camp level can provide an indication of existing options, their benefits and disadvantages. The World Food Programme (WFP), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the Office of Foreign Disaster Assistance (OFDA) have developed reports and handbooks to provide guidance on appropriate cooking technologies and fuels in various contexts (USAID, 2010; WFP, 2012; GIZ, 2013).

Cooking practices are highly context-specific and depend on the food, pots, utensils and stoves available to users. The WHO Household Energy Database[5] can provide general information on cooking practices at national level disaggregated by rural/urban users, education level and wealth. The GIZ-HERA Cooking Energy Compendium provides general guidance on cooking energy technology and practices[6] including basic information about cooking energy, policy advice, designing and planning fuel-efficient stove interventions, cooking energy technologies and practices, as well as designing and implementing woodfuel supply interventions.

4.5 Step 4: Assess the multi-sectoral challenges to access and use of woodfuel

Displaced households face multiple challenges in accessing and using fuel for cooking. These challenges influence the choice and use of specific fuels and cooking technologies, and therefore the demand for woodfuel. A thorough analysis should take into account the following aspects:

- Protection: when leaving camps to collect fuel people may be exposed to harassment, assault and rape. This situation may worsen if scarce forest resources are depleted and may cause heightened tension between host and displaced communities.
- Environmental/forest degradation: the large-scale displacement of people may rapidly deplete forest resources around camps due to the increased demand for woodfuel.
- Nutrition: lack of fuel and use of inefficient cooking methods can result in undercooking of food, skipping meals to save fuelwood, and exchanging or selling food for fuel.
- Health and safety: cooking on open fires or three-stone fires may expose people to lethal respiratory illnesses through the inhalation of toxic smoke. Open fires may also cause burns and increase the risk of uncontrolled fires.

The following indicators are used to assess the exposure of people to risks associated with fuelwood collection and access to cooking fuel:

- average number of fuelwood collection trips carried out by households per week (disaggregated by age and gender);
- average total distance travelled during fuelwood collection trip;
- average number of hours spent collecting fuelwood per week;
- average number of cooking-related burns reported, disaggregated by gender and age;
- proportion of households exposed to indoor air pollution;
- number of people treated for acute respiratory infections disaggregated by gender and age;
- average weekly household expenditure on cooking fuel;

5 See www.who.int/indoorair/health_impacts/he_database/en/.
6 See https://energypedia.info/wiki/GIZ_HERA_Cooking_Energy_Compendium.

- environmental conditions in and around the camp (e.g. fragile, less fragile, stable);
- existence and state of transport infrastructure for the supply of woodfuel and other alternative fuels;
- existence of formal and informal laws and regulations regarding access to land and natural resources;
- relationship between host and displaced populations (e.g. poor, less poor, well-integrated);
- other associated socio-economic and cultural aspects (e.g. livelihood needs and energy market prices);
- woodfuel harvesting and collection practices (e.g. gender and age of firewood collectors), means of transport (e.g. walking, donkey cart, vehicles), collection of dead versus live trees, pruning, thinning and felling.

An overview of the most common challenges associated with the collection and use of energy in displacement contexts may be found in examples and case studies documented in the SAFE guidance material developed by WFP (2012), UNHCR (2014), FAO (2013) and other agencies.[7] However, every displacement context and camp is different and much depends on the relationship between different social groups (e.g. host and displaced communities) and environmental conditions around the camp.

5. Assessing woodfuel supply

Assessment of the targeted area including changes in woody biomass resources is based on a combination of field measurements and temporal change analysis of satellite imagery covering the different land cover classes that provide fuelwood (mainly tree cover and shrub cover). Appropriate satellite data for land cover monitoring can be processed in a semi-automatic way to detect different land cover types and their changes through time. The approaches used by Stehman, Sohl and Loveland (2005), Potapov et al. (2008), Eva et al. (2010) and Hansen, Potapov et al. (2013) have produced successful results for forest area change with acceptable and known precision. In parallel, field measurements have helped to derive biomass expansion factors that can map available woody resources with precision. These have been tested by Goetz et al. (2009), Le Toan et al. (2011) and Galluan et al. (2010) using different imagery and field designs.

5.1 Step 1: Define the sources of woodfuel

The main sources of woodfuel are not limited to closed and open forest land, but also include possible sources of supply such as dedicated energy plantations, shrubland, savanna and agricultural land. Indeed, the share of non-forest areas that supply woodfuel can be substantial. When defining a target area, it is useful to note that woodfuel is typically acquired and/or produced within 15-20 km of the user, whereas traded woodfuel may be collected over longer distances.

7 See the following websites for more resources: www.safefuelandenergy.org/resources/index.cfm, http://cleancookstoves.org/impact-areas/humanitarian/ and https://womensrefugeecommission.org/resources/241-safe-access-to-fuel-and-energy-safe.

Short interviews with local stakeholders should be sufficient to determine the source of woodfuel supply and to identify the relevant resources to be targeted. The range of sources encompasses different types of fuelwood or charcoal of varying quality, and will have a strong influence on how the mapping of resources is performed later on.

Tree and shrub cover are often the primary sources of deadwood used as fuelwood, however fuelwood can also be acquired through pruning. Detailed scrutiny of the degradation of tree and shrub cover and area change requires a minimum spatial resolution of 1.5 m. In the case of dense forest with high canopy cover, a coarser resolution may provide reliable estimates (e.g. Landsat imagery for monitoring resources around IDP camps in dense humid forest of the Congo basin).

Regardless, the available imagery should be able to capture vegetation characteristics including a minimum of visible and infrared spectral information (Earth Observation satellites provide some of this information). Table 1 provides an approximate idea of the achievable spatial resolution and the associated price of different optical satellite imagery suitable for land cover monitoring.

Table 1: Available high-resolution optical satellite images and their indicative cost

	Resolution	**Time coverage**	**Price**
Landsat	30 m	1975-present	Free
SPOT 4	10 m	1998-2013	€0.5/km^2
RapidEye	5 m	2009-present	€1/km^2
SPOT 5	2.5/5 m	2002-present	€3/km^2
SPOT 6-7	1.5 m	2012-present	€5/km^2
QuickBird	0.6 m	2001-present	€10/km^2
WorldView	0.5 m	2009-present	€15/km^2

The following data and information also help to define the sources of woodfuel:

- Strata: three or more vertical strata can be identified including trees, shrubs and herbs.
- Tree status: different tree management types (e.g. pruning, thinning or harvesting) have an impact on the available wood biomass.
- Territorial organization: woody vegetation can be organized in different ways depending on the landscape and management types. Different vegetation forms be linear (e.g. hedgerows), scattered (e.g. agricultural field), sparse (e.g. open forest), mixed (e.g. agroforestry), dense (e.g. forest), or dense and homogenous (e.g. plantation).

Tree components: different tree components can be distinguished including above-ground, trunk, big branches, medium branches, small branches, etc. (Henry, Picard et al., 2011) (Figure 2).

While the collection of local data enables definition of the different sources of supply, the use of default values requires expert judgment to ensure the selected sources of supply are appropriate. In most cases, default values concern total above-ground biomass. Once a tree population is well defined, its geographical distribution can be analysed.

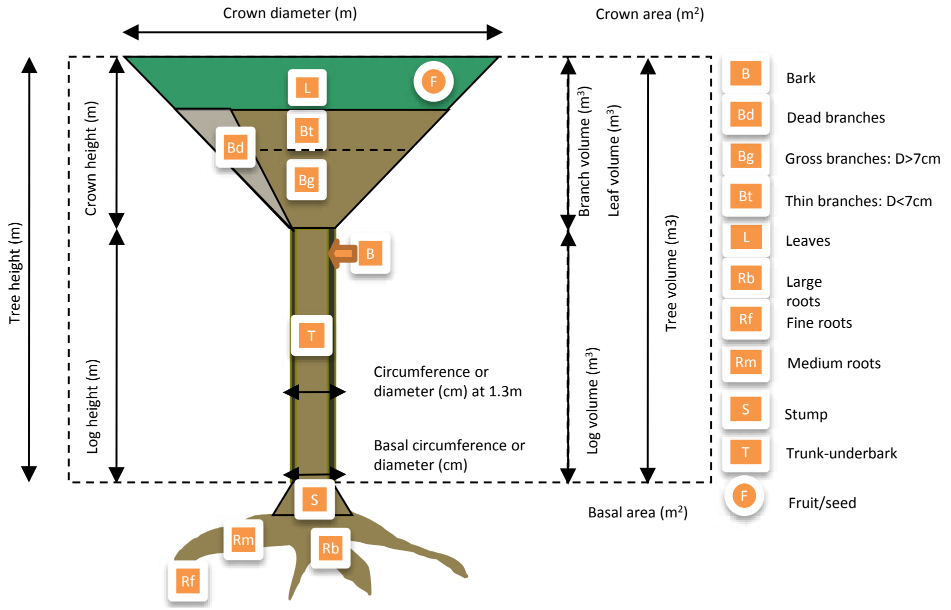

Figure 2: Different tree components
Source: Henry, Picard et al. (2011).

5.2 Step 2: Map the distribution of woodfuel resources

The area to be surveyed depends on the distance travelled by refugees/IDPs to collect fuelwood. In the absence of site-specific information, a 15 km radius is recommended for the assessment. To allow for change detection of woody resources through time and potentially assess the impact of fuelwood consumption on natural resources, while accounting for natural regeneration, at least two dates should be investigated with a sufficient time lapse in between. Satellite or aerial images are the primary source of information used for the development of spatial representations. However, imagery taken too soon after camp installation will not provide information on woody biomass resource change. The greater the spatial, spectral and temporal resolution used, the more robust the estimates. As part of the development of locally specific maps, field surveys are needed to develop a land cover classification system (i.e. the legend of the map), to facilitate interpretation and to calibrate the models used for interpretation.

Detailed land use/land cover inventories remain scarce, but are becoming available at the national and international level. However, it is preferable to use study site data because of the difficulties involved in obtaining detailed values on the evolution of woodfuel resources at two points in time (e.g. before and after the establishment of refugee camps) at the national and international level. The following references may provide additional useful information:

- Remote Sensing Survey of the Forest Resources Assessment (FRA RSS) for the periods 1980–1990 and 1990–2000;
- Remote Sensing Survey of the FRA 2010 for the periods 1990–2000–2010 (Lindquist et al., 2012);
- Globcover 2005 and 2009, which provide global information using LCCS2 and describe three vegetation layers (trees, shrubs and herbaceous);

- Annual updated wall-to-wall tree cover and tree cover change for the period 2000–2012 (Hansen, Potapov et al., 2013).

Further details on data sources for woodfuel supply are provided in Annex 1.

"Step 2: Map the distribution of woodfuel resources" is carried out through a two-stage process: (i) legend creation; and (ii) image processing for land cover area change assessment.

Step 2a: Legend creation

The Land Cover Meta-Language developed by FAO recently became an international ISO standard (ISO 19144-2). Its derived application software Land Cover Classification Systems (LCCS-3) was released in 2015. LCCS-3 relies on the principle that standardizing attribute terminology is more important than the final categories. LCCS works by creating a set of standard diagnostic attributes (called classifiers) to create and describe different land cover classes. The classifiers act as standardized building blocks and can be combined to describe the more complex semantics of each land cover class in any separate classification system (Ahlqvist, 2008). LCCS allows natural interactions between map products and field measurements, as the elements that constitute the legend are the same as those measured on the ground (Figure 3).

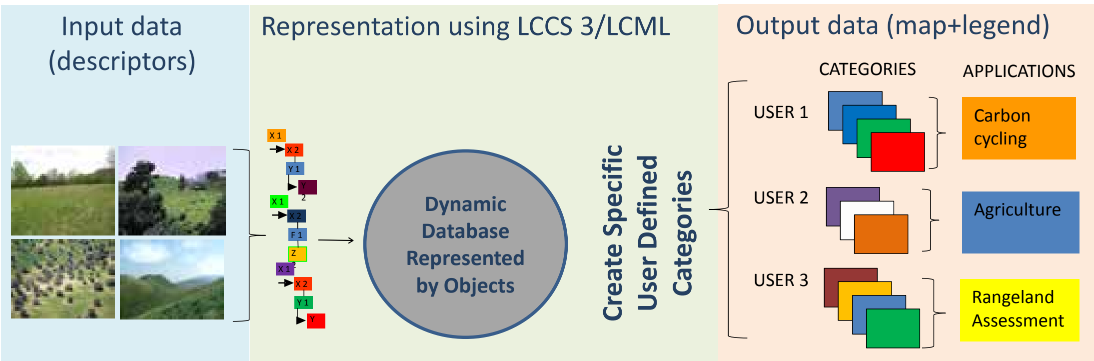

Figure 3: Example of a land cover classification system approach

The legend should be complete and usable without interpretation bias by any user and based on objective criteria describing the land cover. The legend should also be adapted to the available level of information in the imagery, in particular, spatial resolution. For example, if only Landsat data are available, it will be impossible to distinguish dense shrubs from tree cover, and the legend should be adapted accordingly. However, given the costs involved in conducting field measurements, the maximum amount of relevant information should be accumulated for use later for further refinements of the legend or monitoring activities.

It is recommended to use the tools available in the GLCN suite to create and develop a legend.[8]

8 See www.glcn.org/sof_0_en.jsp.

Step 2b: Image processing for land cover area change assessment

Step 2b can be implemented with any set of remote-sensing tools. The following workflow allows for the determination of land cover area and the area of change assessment:

- Calculate the spatial texture of the imagery.
- Run an unsupervised classification over the initial bands + texture (e.g. K-means).
- Manually interpret a random set of points using only the land cover attributes that can potentially constitute the legend (add external elements such as clouds and shadows if needed).
- Run a supervised, pixel-based classification on the cluster output from the first unsupervised classification using a subset of the points (75 percent) as training material (e.g. Minimum Likelihood, Bayes, Random Forest).
- Run an independent segmentation of the bands + texture taking the desired Minimum Mapping Unit into account.
- Compute the occurrence of land cover elements within each polygon of the segmentation.
- Generate land cover class attributes for the polygons based on the values of the supervised classification following the rules described in the LCCS legend.
- Perform independent change detection between the initial imagery dates for both time periods (using the iteratively re-weighted multivariate alteration detection (IMAD) algorithm).
- Constrain the results to follow the change detection mask, based on a site-specific decision ruleset (e.g. best imagery, least seasonality or more complex decision tree based on land use change pattern possibilities).
- Use the remaining 25 percent of interpreted points to generate an accuracy assessment for the classification and provide confidence intervals around the mean for each class.
- Produce a land cover change matrix for the period between the time dates.

Although not compulsory, the use of Free and Open Source Software (FOSS) is recommended for cost reduction, better interoperability and comparability between results across different studies. Tools developed by FAO for forest resource monitoring can be used for this purpose.[9]

5.3 Step 3: Estimate stocks

A sampling design and tree and shrub measurement protocol is used to estimate above-ground woody biomass stocks on the basis of direct measurements taken on the ground. These estimates are associated with the mapped resources to produce a comprehensive stock map. Several field inventory protocols are available,[10] but will need to be adapted to local conditions and the selected sampling design, plot shape and size.

When performing locally specific estimations, field inventories (Figure 4) allow the measurement of dendrometric parameters on well-identified sample plots considered as representative of the targeted population. Models are used to estimate the biomass for the tree components (Picard, Saint André and Henry, 2012). Non-forest formations such as shrubland, homestead gardens, windbreaks, roadside trees and farmland trees represent important woodfuel sources for the rural population and need to be take into consideration.

9 See www.openforis.org/tools/geospatial-toolkit.html.

10 See www.fao.org/forestry/fma/en/.

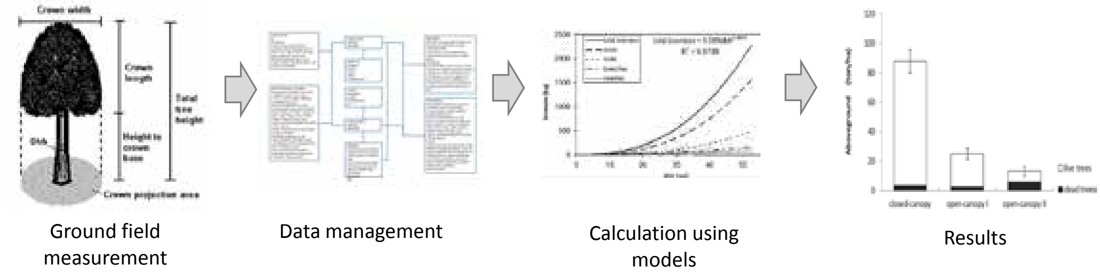

Figure 4: Field inventory scheme to assess tree biomass

"Step 3: Estimate stocks" is carried out through a three-stage process: (i) sampling and plot design; (ii) Field measuring protocol; and (iii) generate spatial biomass data distribution.

Step 3a: Sampling and plot design

Field data are essential to estimate the biomass with precision. However, their collection is costly both in terms of time and resources. The number and distribution of data points per site is therefore determined by the expected output, time and resources available, and the homogeneity of the landscape. The following considerations can help guide the sampling design.

- All classes of the expected final dataset (map) should be illustrated with (at least one) field measurement.
- Points should be systematically or randomly distributed over the surveyed areas.
- Considerations relating to accessibility may result in adjustments to this theoretical framework by incorporating a reasonable buffer around accessibility routes (roads, paths).
- Pre-existing data on land cover and land use characteristics can help design a stratification scheme that significantly reduces the time and cost of field measurements.
- The selected plots should be as homogeneous as possible in terms of land cover classes.

Efforts should be made prior to fieldwork to access the available information and to design accordingly. Many different plot sizes and shapes can be used. It is recommended to use a plot size of 20 m, either circular or square in shape. Square plots are easier to measure when field staff and equipment is limited, but biases are less likely in circular plots. The plot can be composed of a subplot (S) of 10 m and a sub-subplot (SS) of 5 m (Figure 5).

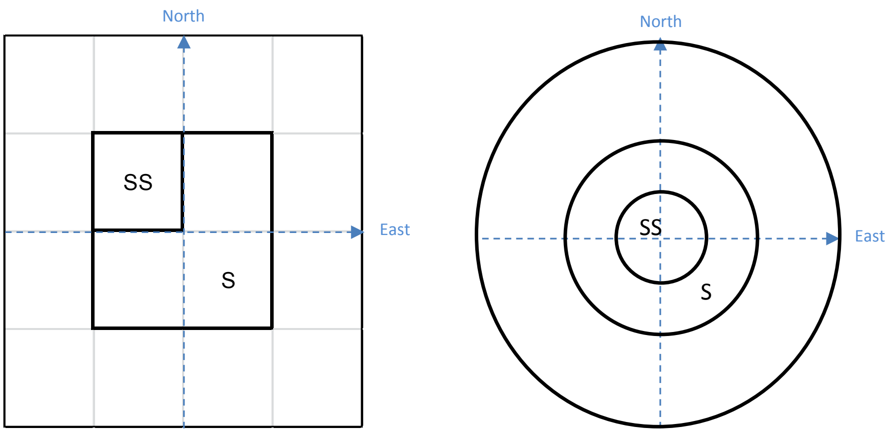

Figure 5: Two different proposed plot shapes

Step 3b: Field measuring protocol

Step 3b consists of measuring dendrometric parameters such as diameter or height for volume or biomass estimation. Two WE and SN orthogonal lines are established within each plot, on which a GRS densitometer is used to determine the canopy cover of the stand. An operator walks the two lines taking a measurement at each step, which is recorded by a colleague (see the canopy cover measuring sheet in Annex 2). Four photographs are taken in the cardinal directions.

All trees and shrubs are measured in the sub-subplot (SS), and trees and shrubs with DBH > 10 cm and DBH < 20 cm are measured in the subplot (S). Only trees with DBH > 20 cm are measured in the remaining parts of the plot. DBH, height, species name and local name are recorded whenever possible.

The required equipment consists of:

- GPS device to reach the location and record the coordinates;
- GRS densitometers to measure canopy cover density;
- Measuring tape + callipers to measure diameter at breast height (DBH);
- Compass to ascertain south-north orientation of the plots;
- Laser range detector to measure distances (optional);
- Clinometer (Suunto) to record the height of trees;
- Field data sheets, pens and pencils;
- Camera.

The output of the field measurements is a database containing plot descriptors with the measurements of all associated trees and shrubs. It can take the form of a table or a more elaborate database.

Step 3c: Generate spatial biomass data distribution

Step 3c consists of combining the field measurements (Step 3b) with the spatial data obtained from the satellite imagery processing (Step 2b). The field plot database contains tree measurements that can be transformed into biomass estimation per plot through the use of appropriate allometric equations. Biomass is generally estimated using allometric models that predict volume or biomass (usually dry) (Picard, Saint André and Henry, 2012). When using volume equations, biomass is estimated by multiplying the volume by wood density and expansion factors (Brown, 1997).

Default data can be obtained from the literature. However, they may not be representative of ecosystems and management types found around refugee camps. When using default data, expert judgment may be necessary to adjust the coefficients.

The subplot and sub-subplot measures must be extrapolated proportionally to the full plot. Estimation of biomass based on dendrometric parameters is performed using the equations available on Globallometree[11] (Henry, Trotta et al., 2012). The extent of the field plots can be drawn on the map and the land cover composition within the derived plots. The occurrence

11 See www.globallometree.org.

of the final classification (number of pixels in each class) is then calculated for the real areal extent of each field plot. Once land cover composition based on LCCS is available for each field plot, it only remains to solve a non-linear system (Figure 6).

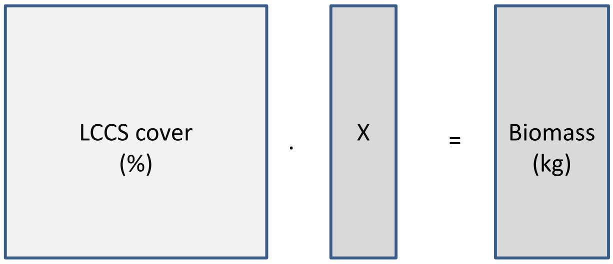

Figure 6: Representation of a non-linear system to assess biomass based on land cover composition

The solution X of the non-linear system shown in Figure 6 gives an average biomass value for each land cover class that can be directly translated into biomass for each polygon of the map.

5.4 Step 4: Assess stock changes

Step 4 consists of measuring changes in the growing stock through one of two methods: stock-difference consists of the measurement of stocks at two points in time to assess stock changes, while gain-loss incorporates all processes that bring about change.

The stock difference method functions by either assigning local biomass estimates to land cover classes at different points in time, or assessing wood biomass changes through field inventory during two (or more) time periods and linking field wood biomass change estimates with land cover change information.

Land cover/use maps from different time intervals should be prepared (i.e. before and after the establishment of refugee or IDP camps). Where possible, monitoring should be performed over time to assess the status and trend of the natural resources and to evaluate the performance of the proposed measurements. National and global mapping products may be limited in their usefulness, as they may not provide information before and after the establishment of camps, and the coarse spatial resolution may not capture actual changes related to tree and forest management and harvesting practices.

In situations where ground field measurements are not feasible, the gain-loss method can be used to derive estimate changes. This method uses default values such as growing stock, mortality, wood field consumption, increase in tree population (number of individuals) and growth. Growth is usually expressed in terms of Mean Annual Increment (m^3 ha^{-1} yr^{-1}) or biomass growth (tonnes ha^{-1} yr^{-1}). Losses are related to mortality and harvest (e.g. by pruning, thinning or clear cutting). In most cases, default data are not representative of ecosystems or crop practices encountered in and around refugee or IDP camps. These values may be accessible in the literature to only a limited degree and may instead be obtained through expert judgment and interviews. However, this method will not provide the same quality of results obtainable through ground field inventory.

A combination of the two methods can be used to compare and adjust the results. In addition, the results obtained by the gain-loss method or stock difference can be linked to the results of interviews with host communities and refugees or IDPs. Once the assessment of stock changes has been performed, appropriate scenarios can be developed.

6. Integrating woodfuel supply and demand

To be effective, field surveys need to identify the relevant interrelationships and the gap between supply and demand. The results of the woodfuel supply and demand assessment are then integrated and used for monitoring, evaluating and planning purposes in the targeted area.

The following estimations from the woodfuel demand assessment can be used in supply and demand integration, taking into account the baseline and the changing scenario in and around refugee camps:

- the density and size of the population and types of social units;
- the quantity and type of woodfuel consumption;
- the distance to collect fuelwood and accessibility;
- the access to other sources of energy;
- the health and protection challenges faced by the population.

Any interventions to increase woodfuel supply must consider these variables for both current and future woodfuel demand. The distance travelled to collect fuelwood and accessibility in the areas surrounding the camps relate both to woodfuel supply and demand for household self-consumption and commercialization in local markets. Therefore, distance and accessibility have an influence on the time required to collect fuelwood and the possibility to facilitate trade in woodfuel (easy access to market and cheaper prices). Access to natural resources can significantly limit the availability of woodfuel in a specific area. For example, national laws can regulate the origin and the collection and production of woodfuels. Natural physical barriers can also limit energy access for local collection and influence woodfuel demand.

Once supply and demand have been integrated, a number of scenarios can be developed based on identification and assessment of the following:

- alternatives for the establishment of agroforestry systems, plantations, hedges and the adoption of less costly energy practices for woodfuel supply;
- potential biophysical risks that challenge the feasibility of different scenarios;
- alternative technologies and energy sources for cooking and heating;
- traditional local practices and challenges linked with energy access for displaced and host communities;
- land use, land tenure and land suitability related to natural resources;
- socio-economic parameters.

The estimates of woodfuel supply are compared with woodfuel demand in emergency or protracted crises with a view to defining: (i) the ratio of woodfuel demand to supply; (ii) the energy deficit; and (iii) the carbon footprint and GHG emission reduction potential.

This comparison can be based on the current situation and on scenarios in which alternative cooking systems and afforestation, reforestation or restoration interventions are introduced. This comparison also forms a baseline for identifying possible risks of degradation and overexploitation of natural resources.

The following section compares estimates for woodfuel supply and demand for cooking with a view to verifying that a comparable amount of biomass is being consumed and has been removed from the environment. Once this step has been carried out, the gap between woodfuel supply and demand can be quantified and possible interventions evaluated for energy consumption reduction or afforestation, reforestation or ecosystem restoration activities.

6.1 Approach 1: woodfuel supply over time

Under the first approach, woodfuel supply over time is expressed as a function of the living woody biomass available at a certain time in a defined area, the productivity of the system, and the use of wood resources for non-fuel purposes (e.g. building materials or poles). All variables are based on dry matter weights of the woody biomass over a specific period. It is assumed that the difference between time 1 (t_1) and time 2 (t_2) is the result of human activities related to wood biomass extraction.

The current woodfuel supply for heating and cooking can thus be calculated using the following equation:

$$E\_supply\_t_1t_2 = E\_live\_t_1 - E\_live\_t_2 + E\_deadwood\_t_1t_2 - E\_other\_t_1t_2$$

where:

- E_consumption_t_1t_2 = estimates of fuel used by the population between time 1 (t_1) and time 2 (t_2);
- E_live_tx = estimates of living biomass at time x in the area within a half-day walking distance from the camp;
- E_deadwood_t_1t_2 = estimates of dead wood produced by vegetation collected by the population between time 1 (t_1) and time 2 (t_2);
- E_other_t_1t_2 = estimates of woody biomass used by the population for non-fuel purposes (construction, poles, furniture, fences) between time 1 (t_1) and time 2 (t_2).

E_deadwood_t_1t_2 can be estimated using the productivity of the vegetation. If a constant productivity (Pr) of the ecosystem (kg/ha/year) is assumed, it is possible to write:

$$E\_deadwood\_t_1t_2 = Pr * E\_live\_t_1 * (t_2-t_1)$$

E_other_t_1t_2 can be estimated proportionally to the population (e.g. use for furniture, construction and fences) as:

$$E\_other\_t_1t_2 = Population * Fratio * (t_2-t_1)$$

The Fratio, that is, the quantity of wood used by each household for furniture and construction expressed in kg/person/year, can be inferred by estimating the wood needs for construction and furniture of a sample of households.

6.2 Approach 2: Woodfuel consumption calculation

Under the second approach, consumption is calculated as a function of the population:

$E\_consumption = Population * Cons * (t_2 - t_1) – E\_external\_t_1 t_2$

where:

- Population = the average population assumed to be constant between t_1 and t_2;
- Cons = the annual woodfuel consumption (kg/person/year);
- $E\_external\_t_1 t_2$ = the quantity of fuel acquired from external sources (distant markets) between t_1 and t_2.

Integration of both of these estimates gives:

$Population * (Cons + Fratio) * (t_2 - t_1) = E\_live\_t_1 - E\_live\_t_2 + Pr * E\_live\_t_1 * (t_2 - t_1)$
$+ E\_external\_t_1 t_2$

The comparison between approach 1 and approach 2 can be seen as a means to verify the validity of the methodology used overall.

Another source of energy may be introduced ($E\_new\_t_2 t_3$), such as tree plantations or sources of bioenergy (e.g. animal dung, grasses and other potential sources of bioenergy expressed in kg of dry matter).

The new situation can be written as:

$E\_consumption\_t_2 t_3 = E\_live\_t_2 - E\_live\_t_3 + E\_deadwood\_t_2 t_3 - E\_other\_t_2 t_3 + E\_new\_t_2 t_3$

Given that the main objective is to preserve living biomass in the future while respecting non-fuel usage of wood resources, the following is assumed:

$E\_live\_t_2 = E\_live\_t_3 + E\_other\_t_2 t_3$

which translates as:

$E\_baseline\_t_2 t_3 = E\_consumption\_t_2 t_3 – Pr * E\_live\_t_2 * (t_3 - t_2)$

As the baseline scenario, one may consider that the use of dead wood for fuel purposes will continue. This implies that the new source of energy to be supplied is:

$E\_new\_t_2 t_3 = E\_consumption\_t_2 t_3 – Pr * E\_live\_t_2 * (t_3 - t_2)$

Several scenarios can be compared against to evaluate the potential for actions such as emission reduction, biomass increase and sustainable management. One potential scenario might consider the avoidance of wood for fuel purposes due to health and safety risks (“health scenario”). Under this scenario, a new source of energy should be provided, in which case the formula would be as follows:

$E\_scenario\_t_2 t_3 = E\_consumption\_t_2 t_3$

7. Case study in one refugee camp in Ethiopia

7.1 Context

A key strategic objective of FAO is to increase the resilience of livelihoods to threats and crises. Accordingly, the Organization has begun to provide support to UNHCR to implement the Global SAFE Strategy at country level. Ethiopia was identified as a priority country for the development of a country-level SAFE strategy and a pilot study was carried out in two refugee camps. The purpose of the study was to test the proposed methodology for assessment of woodfuel supply and demand in and around refugee camps in emergency and protracted crisis situations.

Ethiopia received around 265 402 refugees from South Sudan between December 2014 and June 2015. Currently, a total of 201 748 households/704 816 individuals are accommodated in 23 camps distributed throughout the country, and this number is expected to increase. Refugee populations, as well as host populations in areas surrounding refugee camps, are among the most vulnerable in the world, in part because their access to natural resources is often very limited. Accordingly, the provision and eventual sustainable supply of energy for refugee households has been identified as a crucial gap in response interventions.

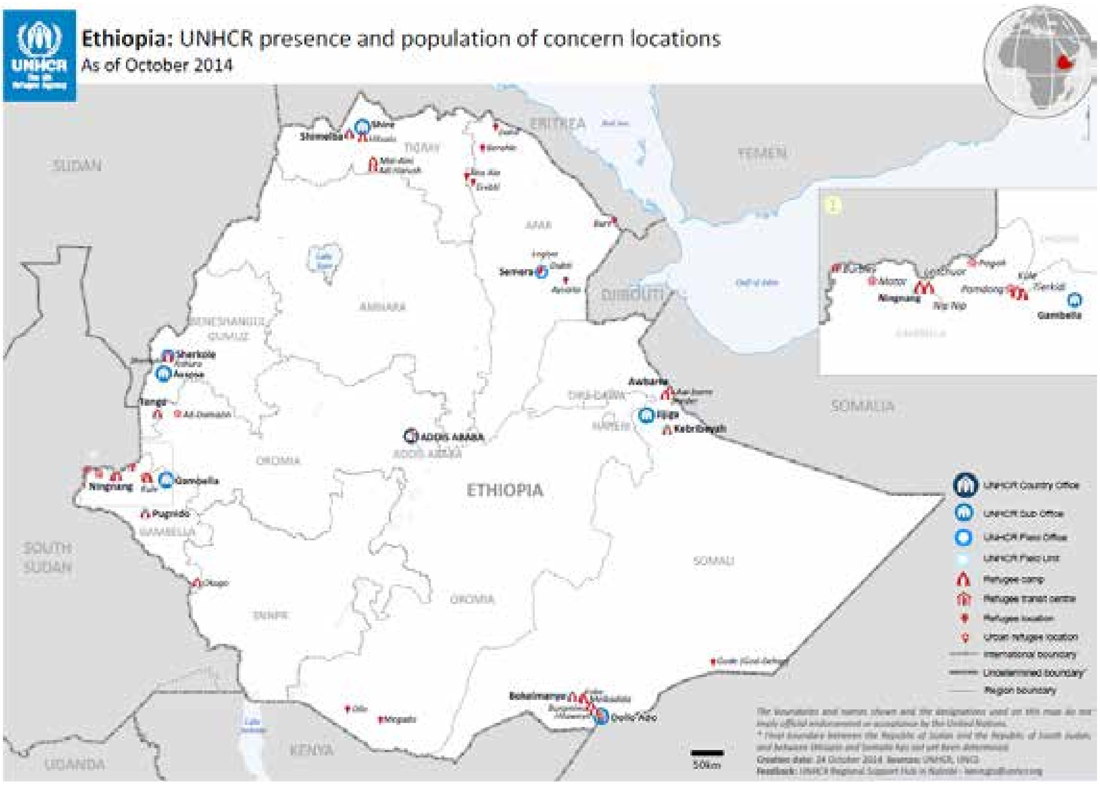

Figure 7: UNHCR presence and population of concern locations in Ethiopia
Source: UNHCR.

7.2 General information about Shimelba camp

Shimelba refugee camp is situated in the Tigray Region in the north of Ethiopia, an area characterized by an extended dry period lasting nine to ten months. The camp began to receive Eritrean refugees in 2004. Shimelba camp represents an example of the long-term impact of a refugee population on local natural resources in the context of a very limited or absent alternative energy supply.

7.3 Assessing woodfuel demand

This section describes a woodfuel demand assessment carried out by the joint FAO-UNHCR mission in Ethiopia. Data collection methods were based on a review of existing information (reports, population census and statistical data), direct field observations, and interviews with field coordinators, site planners, refugees and other key informants.

Step 1: Determine the population and social units

As of 2014, the Tigray Region hosts more than 107 000 Eritrean refugees. Shimelba camp was established in 2004 and Eritrean refugees were relocated from a temporary site. The registered population in the camp today amounts to 6 000 (from a peak of 15 000 in 2007), with a female-male ratio among the adult population of 0.5. The population living in the camp consists of three main ethnic groups: Kunama (39.5 percent), Tigrigna (57.7 percent) and Saho (small minority). The Kunamas are predominantly agro-pastoralists, whereas the Tigrinas come mainly from urban areas and typically have a higher level of formal education.

Step 2: Assess energy consumption

According to interviews conducted in Shimelba camp, the main energy sources for cooking are fuelwood and charcoal, while other fuels such as ethanol and kerosene are very limited. Fuelwood is collected by hand primarily by women and sometimes transported with the support of camels or donkeys. An average fuelwood collection trip takes up to 8-9 hours, with two trips needed per week for a household of four individuals. Total woodfuel consumption per household of four persons was estimated at an average of 4 kg/day and 1.5 kg/day for fuelwood and charcoal, respectively. This corresponds to 6 000 kg of fuelwood and 2 250 kg of charcoal per day for all households in the camp. Schools used 140 kg of fuelwood per day to operate a feeding programme that runs 180 days/year. Camp institutions use about 300 kg of fuelwood and 20 kg of charcoal per day. Small businesses, such as bakeries and coffee shops, used 750 kg of fuelwood and 50 kg of charcoal per day (Table 2).

Table 2: Woodfuel consumption in Shimelba camp

Social units	Number	Fuelwood	Charcoal	Total fuelwood*		Consumption
		kg day^{-1}	kg day^{-1}	kg week^{-1}	t year^{-1}	%
Households	1 500	6 000	2 250	120 750	6 296	92.02
Schools	1	140	-	700	25	0.37
Clinics	1	12	3	189	10	
Administration	3	300	20	2 800	146	2.13
Small businesses	20	750	50	7 000	365	5.33
Total		7 202	2 323	131 439	6 842	100

Note: * Including charcoal on a fuelwood basis.

Assuming a charcoal conversion efficiency of 20 percent, it is estimated that total fuelwood consumption in the camp was 6,842 t yr^{-1}. It is important to ascertain whether the charcoal is produced locally or collected from wood unburned after cooking or other external sources. Charcoal obtained from extinguished fires should not be included, as it is already incorporated within fuelwood consumption.

Step 3: Screen technologies and assess local cooking practices

The most common cooking stoves in Shimelba camp are mud and cement stoves, which burn fuelwood, and metal stoves for charcoal. Refugees and other informants in the camp have suggested the following alternative solutions to reduce pressure on the environment and meet basic needs: (i) the distribution of ethanol stoves and other improved stoves, which have been already tested successfully in the camp; (ii) connection to the national electricity grid, which is near to the camp; (iii) the introduction of biogas technology using faecal matter and organic substrates; and (iv) the utilization of agricultural residues for bioenergy production (e.g. briquetting).

Figure 8: Metal stove for charcoal and cement stove in Shimelba camp
Source: © Arturo Gianvenuti.

Step 4: Assess the multi-sectoral challenges to access and use of woodfuel

Refugees walk long distances to gather fuelwood due to the increased scarcity of woody biomass resources around the camp. This situation creates competition over natural resources, which could lead to conflict with the local community. Household members, and women in particular, have expressed concern for their safety during fuelwood collection. In addition, exposure to smoke inhalation during food preparation represents a direct risk to the health and safety of individuals and women in particular.

There are no communal kitchens in the camp. In addition, the different ethnic groups resident in the camp have different habits with regard to diet and cooking methods.

7.4 Assessing woodfuel supply

Step 1: Define the sources of energy supply

The study used above-ground biomass (twigs, branches and stems) of shrubs and trees as a proxy for sources of woodfuel. The study did not include deadwood lying on the ground, as this data could not be inferred from the available imagery. At the time of writing, no affordable commercial satellite imagery is able to supply this information.

Step 2: Map the distribution of timber resources

Sampling scheme and image selection

In the absence of specific information regarding fuelwood collection around Shimelba, a large buffer area of 50 km radius (785 000 ha) was surveyed, with a view to encompassing the potential effects of the refugee camp on local natural resources.

A sampling strategy was adopted to capture forest land cover and land cover change in an unbiased manner at reduced cost, so as to maximize the linkage between field measurements and remote-sensing data acquisition.

The adopted sampling design was based on a regular decreasing radial intensity of 25 km^2 boxes around the centre of the camp. The central zone around the camp was comprehensively surveyed over a 10 x 10 km area (see Figure 9).

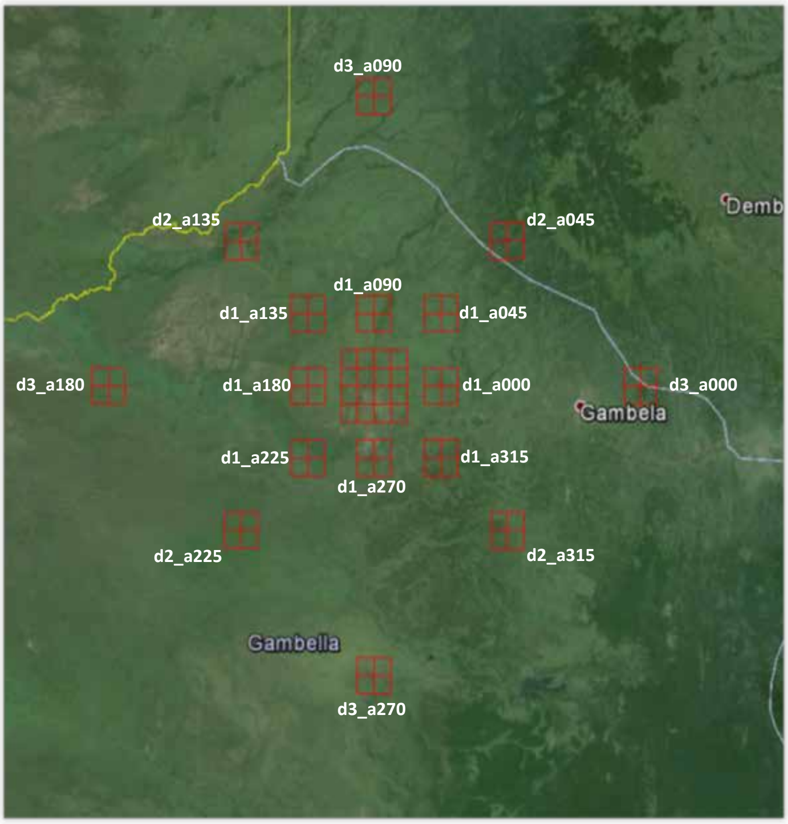

Figure 9: Example of sampling design
Source: Background image taken from Google Earth (TM) on 1 January 2015.

At each of the sampling sites, SPOT imagery was acquired before and after the establishment of the camp in 2000 and 2013 (SPOT 4 and SPOT 6).

Table 3 presents the main characteristics of the imagery.

Table 3: Characteristics of satellite imagery

Shimelba	Before installation			After installation		
Block	Res.	Date	Cloud	Res.	Date	Cloud
Centre	10 m	28/12/2000	0	1.5 m	06/11/2013	0
d1_a000	10 m	28/12/2000	0	1.5 m	06/11/2013	0
d1_a045	10 m	28/12/2000	0	1.5 m	06/11/2013	0
d1_a090	10 m	28/12/2000	0	1.5 m	06/11/2013	0
d1_a135	10 m	28/12/2000	0	1.5 m	23/01/2014	0
d1_a180	10 m	28/12/2000	0	1.5 m	23/01/2014	0
d1_a225	10 m	28/12/2000	0	1.5 m	23/01/2014	0
d1_a270	10 m	28/12/2000	0	1.5 m	06/11/2013	0
d1_a315	10 m	28/12/2000	0	1.5 m	06/11/2013	0
d2_a045	10 m	28/12/2000	0	1.5 m	06/11/2013	0
d2_a135	10 m	28/12/2000	0	1.5 m	23/01/2014	0
d2_a225	10 m	28/12/2000	0	1.5 m	06/02/2014	0
d2_a315	10 m	28/12/2000	0	1.5 m	06/11/2013	0
d3_a000	10 m	28/12/2000	0	1.5 m	06/11/2013	0
d3_a090	10 m	28/12/2000	0	1.5 m	06/11/2013	0
d3_a180	10 m	28/12/2000	0	1.5 m	23/01/2014	0
d3_a270	10 m	28/12/2000	0	1.5 m	06/02/2014	0

The imagery for SPOT 6 was delivered ortho-rectified (with Ref3D) and pan-sharpened. In case of the SPOT 4 imagery, only the black and white panchromatic bands were acquired by SPOT, with the pan-sharpening performed on a Landsat7 image from the GLS2000 covering the scene. The imagery consists of four bands (blue, green, red and infrared) and the acquired product scenes were clipped to the exact extent of the 25 km^2 blocks for both time periods. The projection system is UTM (zone 37 for Shimelba).

Legend creation

For each site, a field visit was planned and undertaken. A dozen field points were chosen randomly from a 500 m buffer zone around access roads close to the camps. The plots were reached by GPS tracking and the following LCCS descriptors were recorded: site bearing, slope, canopy density, land cover information, area homogeneity, natural vegetation and, where appropriate, cultivated areas. This information combined with Google Earth imagery was used to develop a LCCS-3 legend, which encompasses the major land cover items observed on the available imagery, and the development of associated classes (Table 4).[12] Figure 10 provides examples of each class.

Table 4: Land cover classes developed in LCCS-3 and adopted for the study

Closed forest	Cover	Height	Required	Agriculture	Cover	Height	Required
Tree	> 60%	5 – 30 m	Yes	Tree	5 – 15%	5 – 30 m	No
Shrub	10 – 40%	0.5 – 5 m	No	Shrub	5 – 50%	0.5 – 5 m	No
Grass	0 – 100%	–	No	Grass	5 – 100%	0 30–300 cm	Yes
Open forest	Cover	Height	Required	**Urban**	Cover	Height	Required
Tree	15 – 60%	5 – 30 m	Yes	Tree	< 5%	–	No
Shrub	10 – 85%	0.5 – 5 m	No	Shrub	< 5%	–	No
Grass	0 – 100%	–	No	Grass	< 30%	–	No
Shrubland	Cover	Height	Required	**Bare**	Cover	Height	Required
Tree	5 – 15%	5 – 30 m	No	Tree	< 5%	–	No
Shrub	50 – 100%	0.5 – 5 m	Yes	Shrub	< 5%	–	No
Grass	0 – 100%	–	No	Grass	< 30%	–	No
Savanna	Cover	Height	Required				
Tree	5 – 15%	5 – 30 m	No				
Shrub	5 – 50%	0.5 – 5 cm	No				
Grass	30 – 100%	30 – 300 m	Yes				

12 See the LCCS-3 legend for a full description of classes.

Figure 10: Examples of each class

Source: © Rémi D'Annunzio.

Image processing for land cover area change assessment

The following processing steps were undertaken for each block of imagery:

- Calculate spatial texture on the four bands of the imagery (R package: glcm);
- Run an unsupervised classification (25 clusters) over the five bands (four bands + texture), using the k-means algorithm (oft-k-means);
- Run a supervised pixel-based classification on the zones of the k-means output using the RF algorithm (R package: randomForest);
- Run an independent segmentation of the five bands;
- Compute the occurrence of each land cover class within each polygon of the segmentation;
- Burn the values of the supervised classification following the rules described in the LCCS legend.

Several training datasets were tested for the supervised classification steps:

- Dataset 1: points visited during the field mission only;
- Dataset 2: hand-drawn polygons using the full LCCS legend;
- Dataset 3: randomly distributed points, interpreted only with land cover elements comprising the LCCS legend (tree, shrub, grass, bare), and clouds and shadows.

Dataset 1 was clearly insufficient to derive sound classification, while dataset 2 led to confusion between mixed classes (closed forest/open forest, shrubland/grassland). Dataset 3 allowed each LCCS class to be represented in an unbiased manner. It also proved faster to test than dataset 2.

For the purpose of the study, special attention was paid to land cover classes with potential woodfuel resources (i.e. forest, shrubland and savannas). Distinguishing between agricultural land and other forms of grassland would require either careful visual correction and/or a larger time series of images to account for seasonality, however this falls outside the scope of the present study.

Area calculation

The occurrence of each land cover change pattern was computed for each block then converted into an area (UTM is an equal-area projection with each pixels equivalent to 1.5 x 1.5 m). The results were presented in the form of a land cover matrix.

Step 3: Estimate stocks

Sampling and plot design

At each field plot visited the resources present were inventoried on a 20 x 20 m square design. Height, diameter at breast height and species were measured on a stratified basis.

Field measure protocol and biomass calculations

Biomass for each plot was calculated from field measurements using allometric equations. The following equations were tested:

Eq1: $agb = \alpha \times BasalArea^{\beta}$ Titiema et al.(1993)

Where α=0.1529 and β=1.1141

Eq2: $agb = e^{\alpha+\beta\times\log(\frac{Height \times DBH^2}{2})}$ Chave et al. (2005)

Where α=-2.187 and β=0.916

$$agb = \sum \begin{matrix} agb_{twigs} = \alpha_{twigs} \times DBH^{\beta_{twigs}} \times Height^{\gamma_{twigs}} \\ agb_{branches} = \alpha_{branches} \times DBH^{\beta_{branches}} \times Height^{\gamma_{branches}} \\ agb_{stem} = \alpha_{stem} \times DBH^{\beta_{stem}} \times Height^{\gamma_{stem}} \end{matrix}$$

Where $\begin{matrix} twigs \\ branch \\ stem \end{matrix} = \begin{matrix} 0.154 & 1.6688 & 0.2521 \\ 0.03 & 2.3974 & 0.4132 \\ 0.0291 & 1.8384 & 0.879 \end{matrix}$ Mugasha et al. (2013)

A decision was taken to use the Mugasha equations, as they were developed in similar climatic conditions and can be used for trees and shrubs.

Step 4: Assess stock changes

Change detection

Independent change detection was performed using the IMAD algorithm for each block between the two time periods (on the original imagery). This ensured that zones of changes were properly detected, taking into account issues related to seasonality and the presence of clouds and shadows. Classification from the year 2000 for Shimelba was attributed to the corresponding final product for zones where changed occurred (oft-imad, using a 85 percent threshold for spectral dissimilarity to detect change). The two classifications were stacked and each pixel encoded as a two-digit number to account for change and to produce the land cover change matrix.

Software and tools used

All the tools used for this study are free and open source software:

- Working environment: Xubuntu 14.04.1
- Processing code: Perl 5.18.2 and Bash 4.3.11
- Spatial data processing: OpenForisGeoSpatial Toolkit 1.26.6
- Calculations: R 3.1.2
- Visualisation and spatial editing: QGIS 2.6
- Legend: LCCS-3 (in Windows 7)

Results of woodfuel supply in Shimelba camp (Tigray Region)

More changes were observed in the Shimelba camp, as the time period is significantly longer. The degradation of forest and shrub resources is clearly visible, as well as plantation activity.

Table 5: Land cover change matrix in hectares, central block of Shimelba

Classes	**closed_f_t2**	**open_f_t2**	**shrub_t2**	**grass_t2**	**bare_t2**	**nodata_t2**	**Total**
closed_f_t1	1 255	33	28	100	56	0	1 472
open_f_t1	7	783	7	26	17	0	839
shrub_t1	10	11	1 302	69	71	0	1 463
grass_t1	39	35	50	2 978	152	0	3 253
bare_t1	20	23	52	172	3 239	0	3 507
nodata_t2	0	0	0	0	0	99	99
Total	1 332	884	1 438	3 345	3 535	100	10 634

Note: The change of spatial resolution is also evident between the two dates and may lead to over-estimation of changes.

SPOT 4: Shimelba camp, 2000 | SPOT 6: Shimelba camp, 2013

Figure 11: Imagery and classification over Shimelba, 2000 and 2014

Source: Includes material © CNES 2000, © Astrium Services 2013.

Classification: Shimelba camp, 2000 | Classification: Shimelba camp, 2013

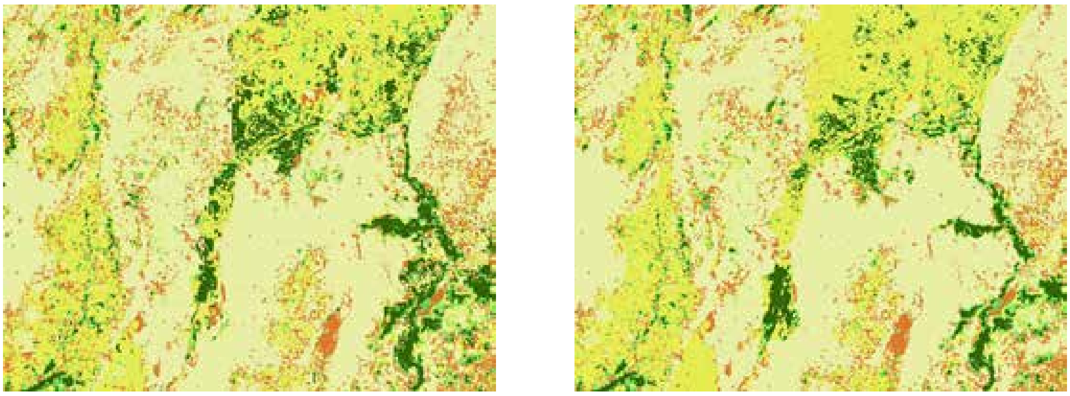

Figure 12: Land cover map of Shimelba camp, 2000 and 2013

Source: Includes material © CNES 2000, © Astrium Services 2013.

Shimelba camp, 2000 | Shimelba camp, 2013

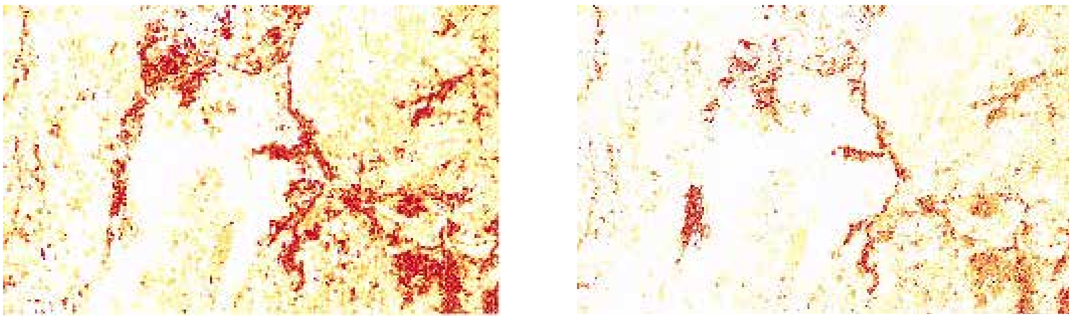

Figure 13: Biomass around Shimelba camp, central zone in 2000 and 2013

Source: Includes material © CNES 2000, © Astrium Services 2013.

Figure 15 shows the tools used at different stages of the classification process. Processing was done using the Open Foris Geospatial Toolkit.[13]

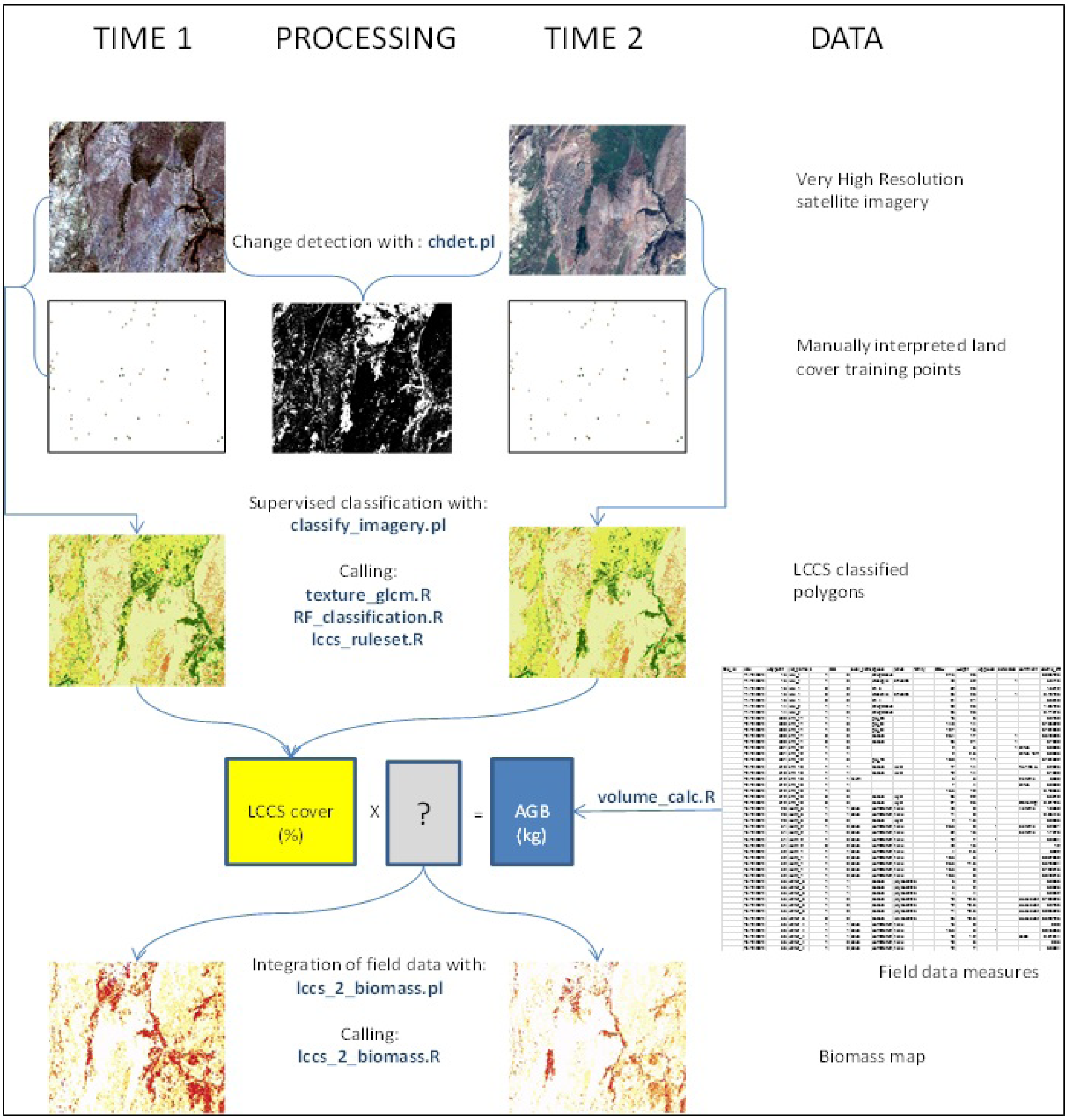

Figure 15: Generic flowchart of image processing and links between scripts

13 Available at: www.openforis.org/OFwiki/index.php/Open_Foris_Geospatial_Toolkit

8. Conclusion

The proposed methodology takes advantage of new technologies, approaches and databases made freely available for assessment of the woodfuel demand-supply chain in displacement settings and its human and environmental impacts. This approach aims to ensure the adoption and adaptation of the assessment process by local and regional managers, as well as technical teams. The manual does not aim to be fully comprehensive, but instead hopes to provide an overview of the different steps that need to be undertaken. Additional documents and websites mentioned in the references and throughout the text will help practitioners implement these steps.

Implementation of the eight proposed steps requires adaptation to local and national contexts, which depends on several factors including the biophysical parameters, human and social conditions, and the available technical, financial and human resources to undertake the analysis. The authors highly recommend the use of the assessment to guide further actions, whether for energy consumption reduction or for afforestation, reforestation or ecosystem restoration activities.

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Annex 1: Useful data sources

The tables below report global or national data sources that can be considered when assessing woodfuel demand and supply.

Data sources to assess woodfuel demand:

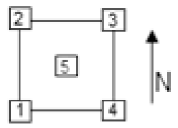
Step	Descriptions	Period	Scale	Units	Source
Step 1	Population trends	Variable	National and displacement	Persons	UNHCR Emergencies database (http://data.unhcr.org) UNHCR Statistical Online Population Database (www.unhcr.org/pages/4a013eb06.html) Internal Displacement Monitoring Centre (www.internal-displacement.org/)
Step 2	Use by fuel type	Variable	Household	Kg/type	World Bank Microdata Library (http://microdata.worldbank.org/index.php/home)
	Source of fuel	Variable	Household	Source type	Living Standards Measurement Study (LSMS) available in the World Bank Microdata Library (http://econ.worldbank.org)
	Main cooking fuel	Variable	Household	Fuel type	MICS3, DHS, LSMS available in the World Bank Microdata Library (http://microdata.worldbank.org/index.php/home)
	Population using solid fuels for cooking	2013	National (rural/urban)	%	WHO Data Repository (http://apps.who.int/gho/data/node.imr.WHS5_512?lang=e)
	Households using Solid fuel as primary cooking Fuel, by type	Update to 2014	Household	%	WHO Data Repository (http://apps.who.int/gho/data/node.imr.EQ_SOLIDFUELS?lang=en)
Step 3	Stove type	Variable	National	Stove type	MICS3, DHS available in the World Bank Microdata Library (http://microdata.worldbank.org/index.php/home)
	Habits and cultural factors	Variable	National	N.A.	WHO Household Energy Database (www.who.int/indoorair/health_impacts/he_database/en/)
Step 4	Hours spent collecting fuel (specified time period)	Variable	Household	Hours	Living Standards Measurement Study (LSMS) available in the World Bank Microdata Library (http://econ.worldbank.org)

Data sources to assess woodfuel supply:

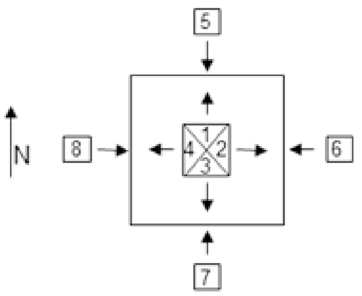
Step	Description	Scale	Units	Source
Step 2	Global Land Cover	Global	ha	http://due.esrin.esa.int/globcover/
	Land cover	Sub-national, national and regional	ha	www.fao.org/geonetwork/srv/en/main.home
	Climate			
	Rainfall, temperature	Global	mm, Celsius	www.worldclim.org/
	Digital elevation model – ASTER GDEM	Local to global	m	www.ersdac.or.jp/GDEM/
Step 3	Basic wood densities	Species	oven dry Mg m^{-3}	IPCC 2003, 2006; http://database.prota.org/ https://datadryad.org/repo/handle/10255/dryad.235 worldagroforestry.org/regions/southeast_asia/resources/wood-density-database
	Biomass Expansion Factor	Climatic zone and forest type	m^3 of wood volume	IPCC 2003
	Above-ground biomass in forests and plantations	Ecological zone and continent	Mg dry mater ha^{-1}	IPCC 2003
	Allometric equations	Species	m^3 $tree^{-1}$ or Mg $tree^{-1}$	(Henry, Bombelli et al., 2013) www.globallometree.org
	Above-ground net volume growth for selected plantation species	Species	m^3 ha^{-1} yr^{-1}	IPCC, 2006; FAO, 2001
	Mean annual increment (MAI)	Species	m^3 ha^{-1} yr^{-1}	(IPCC, 2003, 2006), www.fao.org/forestry/plantedforests/67507/en/

Annex 2: Canopy cover measuring sheet

Plot_ID		COORDINATES	N	E
PLOT_OBS		1		
DATE		**2**		
LOCATION		3		
REMARK		4		

On the spot		Observing the spot from a distance	
Indicate relative position of the coordinates		Distance from the viewpoint to obs poir	(m)
		The bearing of the observed point	deg

PICTURES



Relative Position of photograph

Shot	Position
N*	
N*	
N*	
N*	
N*	
N*	
N*	

CANOPY — Canopy reading: L (leaf); S (sky)

GRSD P.	N -> S	GRSD P.	N -> S	GRSD P.	E-> W	GRSD P.	E-> W
1		16		1		16	
2		17		2		17	
3		18		3		18	
4		19		4		19	
5		20		5		20	
6		21		6		21	
7		22		7		22	
8		23		8		23	
9		24		9		24	
10		25		10		25	
11		26		11		26	
12		27		12		27	
13		28		13		28	
14		29		14		29	
15		30		15		30	

Remarks: Canopy reading = no. of sky/no. of sampling points x 100%

LOCATION		PLOT_ID		PLOT_OBS		DATE	

COORDINATES	NORTH or SOUTH	EAST	ACCESS		SLOPE	SLOPE	DESCRIPTION
1			1	Very good	1	0-7%	Flat to gently sloping terrain
2			2	Good	2	8-13%	Gently sloping to moderately sloping
3			3	Medium	3	14-20%	Sloping to moderately steep, undulating to rolling terrain
4			4	Bad	4	21-55%	Steep to very steep, rolling to hilly terrain
			Other		5	> 56%	Extremely steep terrain, steeply dissected hills
LAND COVER	1a. VEGETATED	1b. TERRESTRIAL		2a. NON-VEGETATED	2b. AQUATIC OR REGULARLY FLOODED LAND		

VEGETATION	GROWTH_FORM	TREES	H (m)	Cover (%)	Min max	Leaf type	
		SHRUBS	H (m)	Cover (%)	Min max	Leaf type	
		HERBS	H (cm)	Cover (%)	Min max	Leaf type	
	CHARACTERISTIC		Floristic aspects				
			Phenology				
			Management practices				
			Burnt status (%)				
			Dead status (%)				
			Damage (type, %)		No, slight, serious, very serious		
			Grazing (intensity%)				
	VEG_ARTIFICIALITY		Natural/semi-natural				
			Cultivated/managed		Irrigated		
					Rainfed		
					Field size		
					Crop rotation		
					Orchard		
					Plantation		

LOCATION		PLOT_ID		PLOT_OBS		DATE	

ABTIOTIC	Artificial surface	Built up			Type		%
		Not built up (dump site/extraction)			Type		%
	Natural surface	Rock surface (bare rock)			Type		%
		Soil sand deposit surface (bare soil)			Type		%
		Termite mound, gilglai			Type		
	Water body/associated surface	Natural		Type		Variation	
		Artificial		Type		Variation	
		Aquaculture		Type		Variation	
FIELD	Homogenity > 300 m around the area			YES		NO	
	Average field size (ha)						
	Field distribution	Bordering field			Average distance between fields (m)		
	Cultivation time factor (< 1 year, more-> years)						
	Water supply/irrigation						
SEASONAL ASPECTS	Natural/semi-natural vegetation			Cultivated fields			
	Dry	Green	Flowering	Ploughed	Initial stage	Full mat. Stage	Harvested
TREES							
SHRUBS							
HERBS							

In densely populated areas such as those found in the context of forced displacement, ensuring access to natural resources, including fuelwood, can be highly challenging. In protracted crises, camps for refugees and Internally Displaced Persons (IDPs) are often established in locations where natural resources are already scarce, and where limited resource access poses the risk of increased food insecurity and social conflicts.

Environmental impacts resulting from the unsustainable extraction and/or use of fuelwood can be long-lasting and cause damage. The sustainability of fuelwood extraction can be evaluated by assessing: (i) the standing woody biomass available for use as fuel (woodfuel supply), (ii) consumption over a given period of time (using woodfuel consumption as a proxy for woodfuel demand), and (iii) the interrelationships and gaps between demand and supply. This evaluation method determines whether the rate at which wood is harvested outpaces the natural or managed rate of woody re-growth in nearby areas and can help to identify options for improving energy use.

This manual presents a methodology for assessing woodfuel supply and demand at the level of the displacement camp through the collection of primary data in the field and remote sensing analysis. The methodology uses a multi-sectoral approach to assess the energy-related needs and challenges of people in both displaced and host communities.

The first part of the manual presents the methodology for assessing demand for woodfuel, which is structured around four sequential steps. Each step provides guidance and tools for collecting data and information, based on the specific targeted area and population. The second part of the manual describes the methodology for assessing the woodfuel supply of the targeted area, based on a combination of field measurements and temporal change analysis of very high resolution satellite imagery for the different land cover classes that provide woody biomass. This section is also structured around four sequential steps.

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