HARMONIZING APPROACHES FOR BIOMASS ASSESSMENT – EXPERIENCES FROM THE PROJECT CEUBIOM

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Note: Article is based on the latest CEUBIOM's deliverable draft[4]

1 INTRODUCTION

The current situation in terms of biomass potential assessment in Europe is very heterogeneous. There are numerous types of assessments currently in use, varying in terms of type of potential, type of assessed biomass, timeframe, methodologies and approaches, basic data used, spatial dimension, frame conditions, etc.

This situation is critical in terms of policy and planning, as the figures and estimations vary considerably. For any consolidated actions or political decisions, such a heterogeneous database is highly problematic, because the credibility of each individual result is always questionable. Thus harmonization of the methods/work processes, and not just the terminology, is essential especially on a national/European level. The terminology should include very clear guidelines on how each country should undertake the biomass potential assessment in terms of input data, biomass types considered, area covered, and methods and assumptions used in order to create a database, which is comparable throughout Europe.

In this context CEUBIOM aims to develop a harmonized method in the assessment of biomass potential for bioenergy, which should be well applicable and relatively easy to implement and in line with the assessed user requirements. The same is needed in the case of Croatia where there is general dissatisfaction with either the quality or with the availability of the data, and where additional issues exists- lack of satellite data.

2 CEUBIOM PROJECT

The aim of the CEUBIOM project is to develop a harmonized approach for European biomass assessment for energy by combining terrestrial methods with remote sensing based applications, with special emphasis on South-Eastern European and Western Balkan countries.

Terrestrial methods such as statistical surveys, ground measurements and questionnaires are frequently used to derive biomass potentials on different scales and for different types. However,

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there are some main drawbacks in using these methods: firstly, the location of the biomass or biomass potential is generally not defined, although statistics are given for specific administrative units, the distribution within a given unit is unknown. Secondly, the figures cannot be checked for accuracy and thirdly, the results are highly heterogeneous, if the persons involved are not well coordinated. A fourth disadvantage would be that remote and less accessible areas are often underrepresented in these studies than well connected regions, which could lead to biased results.

Remote sensing systems are currently being extensively used for assessing land cover and corresponding biomass potential. Various sensor types record different properties, thus advantages and disadvantages have to be considered precisely when using a system. The main advantage of remote sensing is that it provides a very cost efficient way to collect the required information at areas which are usually remote and poorly accessible. Analysis of remote sensing data is also the only practical approach to measure actual land cover and changes at national or international scales.

For indirect biomass assessment, remote sensing delivers the land cover class for a defined area and this information is then combined with information on biomass content of a certain land cover type. This biomass content information has to be derived by other means such as fieldwork. In contrast, direct biomass assessment uses relations between the spectral signal of remote sensing data and the actual biomass content on the ground to directly estimate the biomass amount. Both approaches have advantages and disadvantages and they are both utilized within CEUBIOM depending on their suitability.

The combination of terrestrial and remote sensing methods can be considered as a powerful approach for a variety of reasons, some of which are: lower costs, higher accuracy and better coverage with more spatial details. Depending on these reasons, different combination methods can be recommended. The overall process with its main components is sketched in a very simplified manner in Figure 1. The main input components are the remote sensing products, the terrestrial (statistical) information, local expert knowledge (including literature) and a set of boundary conditions.

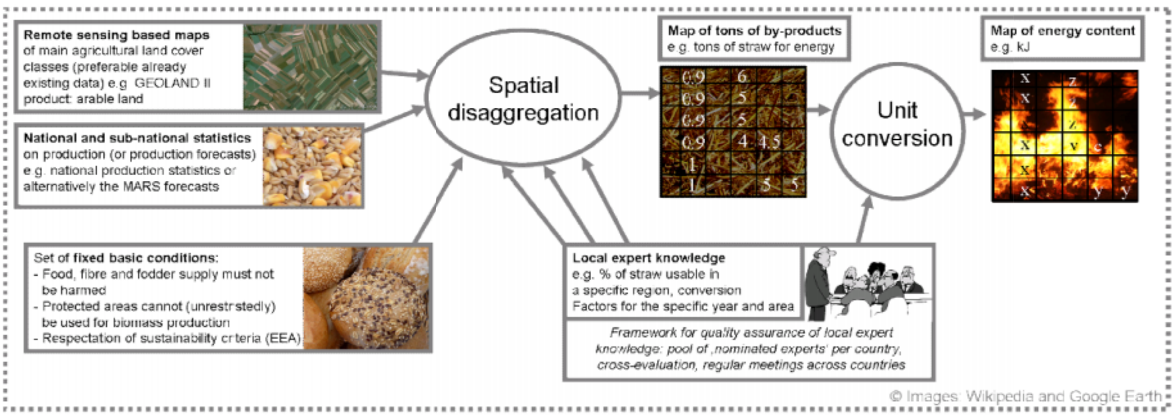

Figure 1: Simplified approach of using terrestrial and remote sensing data for biomass potential assessment for energy.

3 USER REQUIREMENTS

The assessment procedure designed in this study is based on the user requirements collected in the considered countries. The users have been defined as the national ministries and national bodies, which deal with biomass and energy issues. These are in terms of ministries mainly the Ministries of Agriculture, Forestry, Environment, Energy and Economy. In terms of national bodies and agencies, these are for example environment agencies or energy agencies. During the course of the project end-user requirements were duly assessed (see CEUBIOM Deliverable 4.1[5]). The main requirements are summarised as follows:

a) Generate one basic potential with well defined frame conditions (assumptions and restrictions) applicable for many users. This basic potential can be further used for individual potential assessments of specific user requirements.
b) Full update every 3 - 6 years, whenever spatial data, e.g. core service products, are available. In addition, an annual statistical update without a synchronous update of the spatial component can only be done for agricultural biomass.
c) Existing – archived - data should be used in order to keep costs as low as possible.
d) The resulting potential should be to satisfy different purposes, as e.g. internal information, policy and planning, dissemination, reporting and maybe (lower priority) also for subsidies and subsidy control. Potentials with very specific frame conditions, which are only important or available in one country or region, cannot be considered.
e) The requested accuracy ought to be in the range of 80 – 85 %, whereas the errors should be documented transparently and traceable wherever possible.
f) It can be recommended to derive at least three main thematic classes, i.e. 'forest biomass', 'agricultural biomass', and 'other biomass'. Further differentiation should be done based on conditions for accuracy, time or costs as well as based on the existence of data (e.g. if from core services already hardwood/ softwood and crops/ permanent crops/ grassland is available).
g) The product should be a continuous GIS map ranging over a scale of 1:75.000 – 1:100.000. Vector data on NUTS levels can be generated from this base level.
h) The method should not be too complex and be accompanied by training. The processing time (without EO data pre-processing) ought to be in the time frame of 6 – 9 months.

4 SUGGESTED APPROACHES FOR EUROPEAN BIOMASS ASSESSMENT

The initial goal of the CEUBIOM project was to develop one harmonized approach for European biomass assessment for energy with special emphasis on South-Eastern European and Western Balkan countries. During the course of the project, taking into account the user requirements, it became clear that the definition of a single approach will not be sufficient to satisfy all demands. To overcome this issue the project consortium has decided that two approaches should be defined, described individually for the following biomass types: ***forest biomass***, ***annual crops***, ***permanent crops***, ***grassland*** and ***energy crops***. The two suggested approaches are:

- a **basic approach** - designed in order to fulfil most of the user requirements; it implies a rather small role of remote sensing techniques, because the users require a method which is similar to their known procedures and they often do not have the capacity to do extensive remote sensing surveys;

[5] http://www.ceubiom.org/storage/0000/0028/D_4_1.pdf

- an **advanced approach** - contains a set of remote sensing options, which can be combined either in a direct or indirect assessment; advanced methods are suggested, which can only be applied by remote sensing experts and also might need longer processing time and thus increase the costs considerably.

The flow of biomass potential assessment in general - and this also applies for biomass with special focus on energy – is to start from theoretical potential and through technical, ecological or sustainable potential, to finally economic/implementation potential. Hence, the theoretical potential is the base for all further calculations. It is important to mention that any error in the theoretical potential will be retained in all other potentials and also in results of possibly applied modelling approaches.

In order to calculate the technical, ecological or economic potential, several restrictions and assumptions, often also termed as framework or boundary conditions are necessary. Two different sets of frame conditions can be distinguished: first, frame conditions, which **can be harmonized** throughout Europe; and second**, specific frame conditions**, where local expert knowledge (including scientific studies and literature) is needed to generate a useful result. Such frame conditions are in general not transferable throughout Europe without losing usability and accuracy in the results.

5 DATA SOURCES

Tere are two main groups of data sources – terrestrial data sources and those coming from remote sensing techniques.

5.1 TERRESTRIAL DATA SOURCES

For forest-related biomass, the main sources of terrestrial data available in most countries are the National Forest Inventory (NFI) and Forest Management Plans (FMP). The availability of NFI and FMP data as well as the year of the last update was analyzed within CEUBIOM, and it shall be available in the last deliverable. In addition to NFI data and other national data sources, EUROSTAT provides statistical data on wood production and forestry[6].

For agricultural biomass the terrestrial data sources mainly consist of the statistical agricultural datasets, which are available from various national and regional sources, as well as from EUROSTAT at the European level.

In case of the energy crops, the statistical data is generally very poor, and in usually there is no separate energy crops statistics within official national statistics.

5.2 REMOTE SENSING/SPATIAL DATA SOURCES

The two main tools for agricultural applications are CORINE Land Cover (CLC) and the GEOLAND2 core service products developed with the Geoland2 project part EUROLAND.

[6] www.eurostat.ec.europa.eu

CORINE Land Cover is a geographic land cover/land use database encompassing most of the countries of the European Community and the majority of the Central and East European countries.

One of the large projects in the European GMES initiative is the currently ongoing GEOLAND2 project[7]. One part of this project is the component called EUROLAND, which will develop operational methods to produce a high resolution generic land cover layer of Europe. It can be expected that the most urgently needed HR layers will be realized as part of the proposed content for GMES Initial Operations (GIO).

For areas missing these remote sensing based maps, the processing steps in order to produce them are given in the project deliverable. When comparing the existing agricultural classes of GMES GEOLAND LCC with the crop classification scheme needed for accurate biomass assessment, it becomes clear that they are not at the same hierarchical resolution.. In order to obtain information on crop-distribution, three options are feasible:

1) use national land use/cover classifications with more detailed thematic classes (e.g. LaND25 (Germany))
2) rely on local/regional experts to provide additional information concerning crop distribution
3) simple generalization based on the existing European classifications.

A general drawback in using existing land cover or land use classifications is the time gap between the satellite data acquisition and the timeframe for the statistical data. Pan-European classifications are only updated approximately every 5 - 10 years. The same is usually valid for most national land use classifications. Land use statistics though, are updated on a yearly basis for most countries. So land use statistics and land use area defined by the classification might not be equal leading to problems in the spatial distributions and errors in the final biomass values.

6 BASIC APPROACH

The basic approach, despite using remote sensing techniques only to a limited extent, has multiple advantages. One of advantages refers to the spatial dimension. Through the land cover maps, the potential can be geo-located and thus enabling the stakeholders to obtain a more detailed view not only on the amount but also on the distribution of the biomass. Further, the basic approach is designed to make optimal use of existing products and services at national and European level- meaning that this approach is relatively cheap.

In the case of basic approach, basically all input information is available through other projects or initiatives, meaning that the combination of these input data can be done quite fast. Although the basic approach strongly relies on local expert knowledge in order to guarantee the incorporation of local conditions, the use of a quality assurance system as suggested by CEUBIOM will significantly improve the harmonization. And finally, the basic approach is applicable to all considered countries- it relies on existing information and thus it is secured, that all needed input data are available or can be substituted.

[7] www.gmes-geoland.info

EXAMPLE: BASIC APPROACH FOR FOREST BIOMASS ASSESSMENT FOR BIOENERGY

The basic approach for forestry biomass is sketched in Figure 2 exemplarily. For the full explanation of the individual steps and also details on the approach for agricultural crops, the reader is referred to the CEUBIOM Deliverable D4.3.

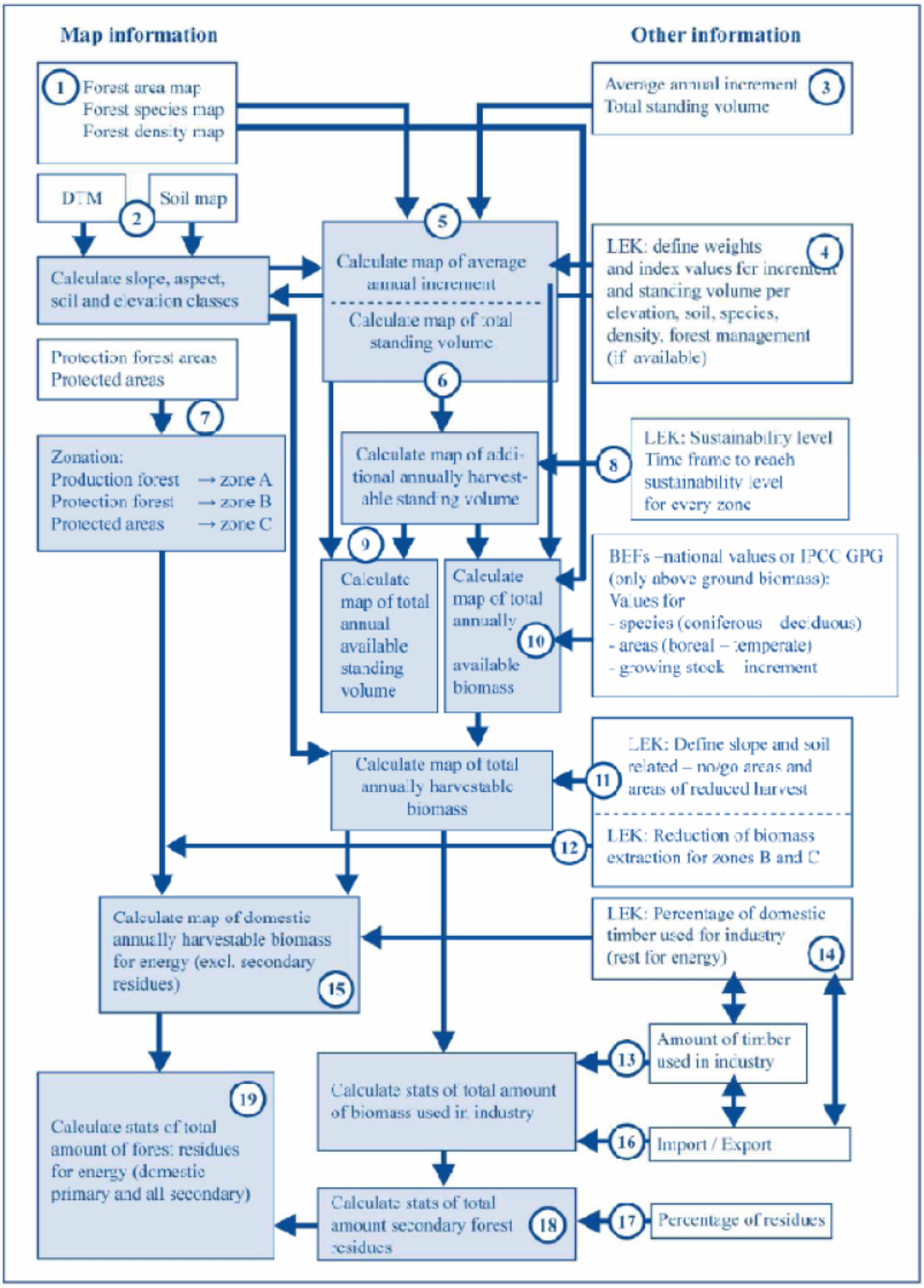

Figure 2 Process workflow for the basic approach - forest biomass for energy

7 ADVANCED APPROACH

In comparison to the basic approach, the advanced approach has more thematic and spatial details using target-oriented land cover classes instead of existing ones. Classes that are specifically selected for biomass for energy can be distinguished thus leading to a more detailed result. The use of more detailed data can also improve the classification accuracy. Sometimes an independent assessment is needed, especially if existing initiatives are depending on political decisions and may be on hold for some time. In this case, the advanced approach is an independent and suitable alternative. Although, generally the use of local expert knowledge is important in order not to 'equalize' circumstances, which are not equal in different countries and regions, using more advanced tools helps to minimize the efforts for local experts while at the same time keeping the quality and (correct) heterogeneity of the output.

Finally, the advanced approach enables faster updates. In case of big projects, such as European-wide land cover maps or statistical assessments, the delivery time is sometimes quite long for the basic approach and the results might not be sufficiently up-to-date. With the advanced approach, national assessments can be done faster according to the specific temporal needs.

EXAMPLE: ADVANCED APPROACH USING LIDAR DATA FOR FOREST BIOMASS ASSESSMENT

Very accurate results for estimating biomass can be obtained by using tree species, stem number and diameter at breast height (DBH). However, DBH can only be measured in the field, which is for large areas very time consuming and costly. Instead of DBH, tree height can be measured more efficiently by remote sensing. Thus as already mentioned in, the key parameters to estimate forest biomass from remote sensing are the following[8]:

- forest area
- tree species (-mixture)
- tree density (crown cover or stem density depending on the data source)
- tree height

Forest area, tree species and crown cover as a density parameter are foreseen to be available through the GMES core service products for land (see GEOLAND 2 project: [GEOLAND2, 2009), but they can also be generated separately from Lidar data or combined optical/LiDAR data. In order to generate tree height, a DTM (digital terrain model) and a DSM (digital surface model, i.e. the height of the canopy) are needed.

While there are several options to generate a DSM: LiDAR, photogrammetry and interferometric SAR processing (InSAR); LiDAR is the only accurate remote sensing source for generating a DTM for forested areas. Thus LiDAR is the best option to generate tree height, although at high costs.

It has to be mentioned, that due to the high costs, the realization of a LiDAR based advanced approach would probably never be done for biomass estimation for energy purposes only. In contrast, intermediate results on the way to a biomass potential for energy, which are basic forest parameters, would be beneficial to a number of users, such as: forest management and

[8] CEUBIOM Deliverable 4.2. http://www.ceubiom.org/storage/0000/0077/D_4_2.pdf

administrations, national forest services, national parks, managers of protection forests, forest industry, forest owner associations, etc.

Airborne LiDAR (Light Detection and Ranging) is an active remote sensing technology emitting laser pulses in the visible or near infrared wavelength and measuring the time lag between the emission and the return of the reflected pulse(s). If a laser pulse is send out over a vegetated surface such as forest, multiple reflections can occur. Typically the first reflection (first pulse) represents the height of the canopy, while part of the beam penetrates the canopy and is reflected as a last pulse from the ground. Filtering techniques are used to separate ground and canopy signals [Wack and Wimmer, 2002]. This kind of data has proven to be very useful to derive main forest attributes, as a large amount of scientific papers have been dealing with this issue over the past decade. Some early works were done in the frame of the HIGHSCAN project [Hyyppä and Hyyppä, 1999, Hyyppä et al., 2000, Hyyppä et al., 2002, Ziegler et al., 2002]. There are basically two different ways of deriving forest parameters using first and last pulse data: either on an individual tree basis [Koch et al., 2006, Pitkänen et al., 2004] or on stand level [Andersen et al., 2003, Barbati et al., 2009, Koch et al., 2009, Næsset, 2002, Wack and Stelzl, 2005]. For individual tree measurements, the most frequently derived forest attributes are tree position, height, crown width, crown base height and as secondary products diameter at breast height (dbh), basal area and timber volume of the individual trees. Few studies have been trying to extract species information, e.g. [Donoghue et al., 2007]. Stand-level forest attributes are often timber volume or above-ground biomass [Barbati et al., 2009, Hollaus et al., 2009].

A combined single-tree and stand-wise approach is suggested to derive the following forest parameters at a stand level: age class, species mixture, crown cover percentage, dominant tree height, standing timber volume and total above ground biomass. In this regard, the individual tree detection process is only an intermediate result for the derivation of the stand-wise attributes. The aim of this development was to generate practical and operational approach of the use of airborne LiDAR data in combination with multispectral satellite images for a large area forest mapping. The idea behind this development was to significantly reduce the amount of both field work and manual digitizing work and thus to reduce costs for the forest inventory. This or a similar approach has been used for forest inventories i.a. in Austria, Switzerland, Germany, Norway and Finland.

8 SHORT OVERVIEW OF THE SITUATION IN CROATIA

According to studies made for various types of biomass, technical potential is assessed as 39 PJ plus additional theoretical potential of 11 PJ. A major source for such energy is the wood mass (fuel wood, residues and wood waste from the wood processing industry). Such amount could theoretically cover 10% of energy requirements in Croatia. Various different studies estimate this potential of biomass in the range between 50 – 80 PJ available in 2030. This makes biomass the second most significant renewable source of energy after large-scale hydro.

Methodology that was analyzed was the one that has been used for biomass assessment in Croatia within the national project BIOEN (funded by Croatian Government, and performed by Energy Institute “Hrvoje Požar”, 2001). The objective of BIOEN was to enhance use of bioenergy in Croatia by assessing biomass potential and suggesting further activities. It mainly consisted of statistical data combined with expert's judgement, mostly in form of defining constraints and looking for figures within the constraints (social, economical, environmental etc.).

Data collected are not in a database, and is available in printed format only. It is openly accessible to anyone, and is available at Energy Institute "Hrvoje Pozar". Scale of methodology is on national level with some special considerations on specific regions (for example, forestry biomass data was given in accordance with forestry regions). The methodology uses existing data – snapshots few years in the past. Snapshots were not universally used for all biomass types, but depend on data availability. Future trends are predicted for few years in the future, mostly until year 2015. For assessing possibilities of bioenergy use, few main potential categories were identified and assessed:

- Theoretical,
- technical (reduced by various factors like biological minimum that needs to be left on the fields or in the forests, or biomass potential that cannot be used because of diversification of livestock fund),
- additional theoretical potential (that could be obtained if some advanced techniques are being used - fast growing energy forests, investment in degraded forests, using burnt sites or growing energy crops), and
- realizable potential (usually shown as a percentage of theoretical available potential).

Apart from the BIOEN national program, other studies used for biomass assessment were IEA BIOENERGY Task 29: Socio-Economic Drivers in Implementing Bioenergy Projects, Energy potential of biomass from wood processing industries in Zagreb County, Energy potential of biomass in Istria and in Split County, Acceleration of the Cost-Competitive Biomass Use for Energy Purpose in the Western Balkan Countries and Strategy for a modern charcoal industry in Croatia.

Upon request from the Ministry of Regional Development, Forestry and Water Management, Forest Management Plan was prepared. Forest Management Plan will keep data on all private and national forests about: forest area, wood resources, yield, forest protection data, list of tree types, age classification, data on regions, balance for each region, wood consumed per capita etc. It consists of textual chapter, chapter with tables and chapter with maps (including GIS data).

Overall, biomass as a modern energy source in not yet quality recognized in Croatia – practically all biomass in Croatia is used inefficiently for household heating. Even though studies on biomass potential are showing that energy from biomass is the second highest renewable potential, after big hydro power plants. Although feed in tariffs were introduced in Croatia for electricity production from biomass (which are the highest in the region) there are very few projects being planned.

In the BIOEN programme, a wide range of data was prepared and gathered together for the first time. Most data collected were statistical data, but that data were combined with experts' judgement and the result was recognized as a quality work. Results from it were used in defining each energy strategy that came afterwards. What might be improved with further effort is that biomass overview is not given completely on a regional scale but mostly on a national, and the fact that time scale was mainly focused for two years only (both very outdated), and progress in future is shown only for biomass from forestry. Further, there is weak or no availability of the satellite data for Croatia. Thus, new studies that would follow the same methodology or new methodology that would overcome the weak points from the existing one would improve understanding of biomass potentials in Croatia and help in planning biomass use in energy production. Harmonized approach, as suggested by CEUBIOM could have significant positive impact in Croatia, as well as in other countries of the region.

9 CONCLUSION

In SEE region as well as in rest of the Europe there is a clear need for harmonization of biomass assessment approaches and up to date do systematic work on the issue has been done. CEUBIOM will present the possibilities for approaches harmonization keeping in mind different country conditions. Throughout the surveys conducted during the project it was clear that it is a general opinion of actors within the region that availability and quality of data are critical issues.

Although the initial aim of the project was to develop one universally applicable approach, throughout project development it became clear that only one approach could now meet all the needs. Thus two core approaches were proposed – basic and advanced. While basic approach should be generally applicable, its limited ability to deal with the details which are sometimes required, showed the need to use a more 'sophisticated' approach in some cases.

As in Croatia there is limited availability of ready satellite data products, the advanced approach would be more suitable. However, once the approaches become harmonized on the EU level it is likely that as part of the Croatia's accession process to the EU the needed data would become available and both approaches could be equally used.

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