SPATIALLY EXPLICIT ASSESSMENT OF AGRIFOOD BIOMASS RESOURCES - TOWARDS A METHOD FOR SMALL-SCALE ASSESSMENTS

Kuisma M., Aro-Heinilä E., Lehtonen E., Tuomisto J., Kahiluoto H.
MTT Agrifood Research Finland, Plant Production Research, Lönnrotinkatu 3, 50100 Mikkeli, Finland.
Tel:+358 40 8408866. miia.kuisma@mtt.fi
MTT Agrifood Research Finland, Economic Research, Luutnantintie 13, 00410 Helsinki, Finland.
MTT Agrifood Research Finland, Plant Production Research, 31600 Jokioinen, Finland.
MTT Agrifood Research Finland, Economic Research, Ruralia Institute, Kampusranta 9 C, 60320 Seinäjoki, Finland.
MTT Agrifood Research Finland, Plant Production Research, Lönnrotinkatu 3, 50100 Mikkeli, Finland.

1 INTRODUCTION

During recent years there has been a growing interest in biomass resources especially in connection with energy utilisation. Policy targets and regulations have been introduced for climate change mitigation and for substituting renewable energy sources, including biomass resources and bioenergy for fossil energy. Biomass resources represent not only energy sources but they also contain substantial amounts of nutrients. In fact, a significant fraction of energy replacement can be achieved by substituting inorganic fertilizers with biomass-based nutrients. In addition, mitigation of eutrophication through nutrient recycling is an additional means of generating environmental benefits. Consequently, there are increasing numbers of business options for corporate social responsible business in the bioenergy sector.

The rapidly increasing interest in biomass utilisation has created a strong demand for assessments of biomass potential for a variety of purposes. Biomass assessments were recently reviewed by Smeets et al. (2009), Dornburg and Faaij (2008), Rettenmeier et al. (2008) and Berndes et al. (2003). The scopes of the reviews reflect the focuses of assessments at the global scale (Dornburg and Faaij 2008, Berndes et al. 2003) or global and supra-national (EU) scales (Smeets et al. 2009, Rettenmeier et al. 2008). Most of the studies reviewed by Smeets et al. (2009) and Berndes et al. (2003) were oriented to future scenarios. Smeets et al. (2009) classified the wide range of approaches and methodologies that were employed in the assessment studies. The conclusions reached in the reviewed studies differed greatly, largely due to the range of estimates for land availability (Smeets et al. 2009, Berndes et al. 2003), yield levels of energy crops (Berndes et al. 2003) and intensification of agricultural production (Smeets et al. 2009).

Various questions need to be asked that go beyond the focus of the reviewed studies. Such are questions raised at varied local, regional or national levels regarding exploitation of the currently weakly utilised resources for a range of bioenergy, nutrient, carbon and biomaterial products to supply the emerging market with the ultimate aim of mitigation of climate change and eutrophication. Planning biorefinery activities relies on assessments of biomass availability, including biomass properties, required transportation, costs and potential demand for products. Clients include those involved in biomass supply chains and biorefining activities and product use, and those concerned with regional, national and EU level policy frameworks and administration.

Biomass resources are typically scattered and transportation costs are significant determinants of the technical and economical potentials. Thus, for practical planning of biomass utilisation, accurate data are needed on local conditions and available and achievable biomass resources for varied spatial scales. Previous approaches for assessing biomass potentials have not addressed the various sub-national, regional and local assessment scales satisfactorily due to insufficient resolution. In addition, regional and aggregated data sources have often been used, allowing only generalised assessments to be made. Furthermore, mainly forest and crop-based biomass is included in assessments, while other important agrifood biomass types are excluded. Concerning potential markets, organic amendments and recycling fertilizers have hardly been included in the demand analyses. This paper reviews assessments that address such gaps in needs.

We review previous biomass resource assessments which address regionally achievable, spatially explicit resources. The aim is to identify the available approaches and methods and their possible shortcomings. In addition

to biomass supplied by dedicated energy crops, agrifood residues from primary production, processing and consumption stages were also included. In addition, forest biomass studies were considered since questions of scattered location are typical to both agrifood and forest biomass assessment. Since biomass represents both energy and a nutrient source not only volumes and energy properties but also nutrient properties were included. We study, what kind of questions have been addressed by the spatially explicit biomass resource assessments performed and what kind of approaches, methodology and data have been used to address these questions. We also examine what kind of relevant methods and tools have been developed. To our knowledge, such a study has not been undertaken to date.

2 MATERIALS AND METHODS

The first stage of the literature review of spatially explicit biomass resource studies included journal articles, project reports and on-going European studies. A conceptual model for spatially explicit assessment of all agrifood system biomass resources was created based on the findings.

3 RESULTS AND DISCUSSION

3.1 Spatially explicit studies

Preliminary results of the review of literature on spatially explicit studies of biomass resources indicated that two principal questions were addressed: 1) What is the regional biomass potential? 2) What would be an appropriate location for a biomass processing plant in a region? The studies were mainly resource-focused, bottom-up approaches but were frequently linked to demand-drivers associated with energy and climate policy targets. Totally 42 studies were reviewed (www.mtt.fi/valuewaste → Publications). Four studies solely concerned dedicated energy crops and 10 studies only addressed assessment of forest biomass sources, while others covered either individual biomass types or various combinations of agrifood and forestry crops and residues. Only a few studies concerned agrifood biomasses from all stages of the food chain: primary production, and primary, secondary and tertiary residues. Aquatic biomass resources have invariably been ignored. Nutrient and carbon contents of the biomass resources and demand for organic amendments and recycling fertilisers have largely been excluded. Data sources for biomass volumes were mostly regional, while spatially explicit biomass data of higher resolution were rarely found. Integrated assessment modelling methodology and modelled data were particularly used in the location studies.

When it concerns methods and tools, most of the advanced ones were developed and applied for forest biomass assessments, e.g. WISDOM (Ghilardi et al. 2009, Masera et al. 2006), BRAVO (Noon and Daly 1996) and several GIS-based decision support systems (DSS) (Frombo et al. 2009, Panichelli and Gnansounou 2008). For agrifood biomass, e.g. ASABE (Batzias et al. 2005) and BIOLOCO (Geijzendorffer et al. 2008, Diekema et al. 2005) were developed and applied. By the current methods and tools, only a limited number of agrifood biomass types were covered, mainly crop-based biomass and manure only. Nutrient and carbon properties of the biomass resources were not included in the tools, not even in the most advanced tool BIOLOCO. The DSS, on the other hand, included numerous optimisation targets and therefore are often too laborious for answering practical questions. For practical purposes, it is important to be able to assess the overall biomass resource potential simultaneously, because it is often possible to be processed with the same technology. There is thus a demand for spatially explicit bottom-up assessment methods which serve various local, regional and sub-national needs and cost-efficiently cover overall agrifood biomasses.

3.2 Towards an adequate spatially explicit method

We outline a preliminary conceptual model of an adequate method for spatially explicit small-scale agrifood biomass assessment (FIGURE 1). The operating system of the method is based on a hierarchy of a practical sequence of typically asked questions concerning the spatial location and availability of the biomass resources. Depending on the questions, varied databases and approaches will be utilised. The databases for the method consist of point locations of the primary data and the data based on key variables for those biomass types for which the primary data is not available in the accessible databases.

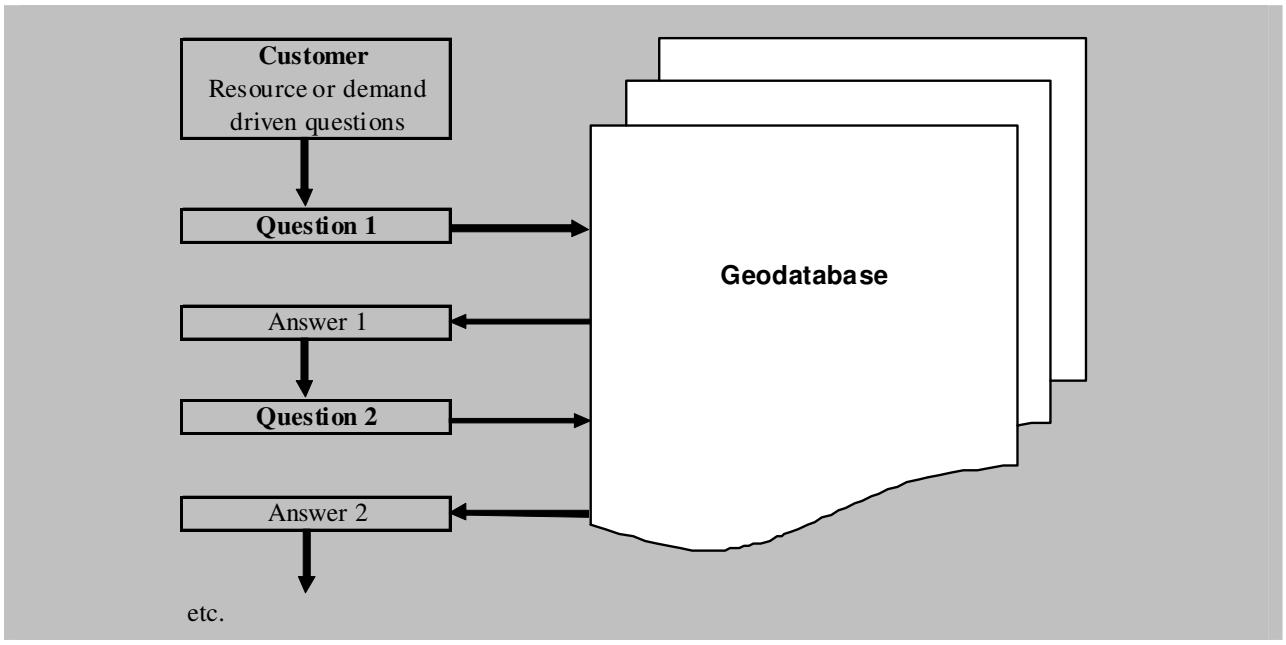

FIGURE 1 **Conceptual model**

4 CONCLUSIONS

The review of the biomass assessment literature and the available tools showed a need for a cost-efficient tool serving assessments of overall agrifood biomass types at varied spatial scales, also addressing for a demand of nutrient and carbon products. Due to a broad range of spatial scales and biomass types from varying sources, we concluded that a hierarchical structure of the approach is required. Further we concluded that the tool has to utilise calculated coefficients based on key determining factors specific for those biomass types for which comprehensive primary data is not easily accessible.

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