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Spatial analysis of residential fuelwood supply and demand patterns in Mexico using the *WISDOM* approach

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Abstract

A *WISDOM* analysis was conducted in Mexico in order to: (1) identify fuelwood (FW) *hot spots* in terms of residential FW use and availability of FW resources for the year 2000, and (2) estimate net CO_2 emissions from the non-renewable use of FW. *WISDOM* (woodfuel integrated supply/demand overview mapping) is a spatially explicit method, based on geographic information system (GIS) technology, which ranks a set of spatial units according to a group of indicators, in order to identify woodfuel priority areas or woodfuel *hot spots*. A comprehensive analysis was conducted, integrating full coverage national data on land cover classes, land cover change maps (1993–2000), geo-referenced population censuses (1990 and 2000), and a meticulous review of the international literature and Mexican case studies. Following a spatial multi-criteria analysis, 2395 counties (out of a country total of 2424 in year 2000) were ranked based on the number, density and annual growth rate of FW users; the percentage of households that use FW; the resilience of FW consumption, and the magnitude and likely trends of FW forest resources. The *WISDOM* analysis allowed the identification of 304 high priority counties (HPC), which showed a spatially aggregated pattern into 16 clusters. HPC cover 4% of Mexican territory and represent 27% of total FW consumption. We estimated that 1.3 Tg CO_2 y^{-1} are released to the atmosphere by non-renewable FW burning, a value that represents less than 1% of Mexican total annual CO_2 emissions in 2002. The results of the analysis show that *WISDOM* is a useful tool for both focusing resources to critical areas where action is more needed and to obtain more accurate estimates of the impacts associated to FW use.

Keywords: Fuelwood supply/demand; Fuelwood priority areas; Spatial patterns analysis; CO_2 emissions; Mexico

1. Introduction

In developing countries, 80% of the wood removed is used for cooking, heating, and boiling water by approximately 2.4 billion people [1,2]. On average, woodfuels satisfy 15% of developing countries primary energy consumption [1]. Although the indubitable role of woodfuels as a major energy source in these countries, its patterns of supply and demand, and its associated social, economic and environmental impacts are poorly understood [3].

The precise magnitude and likely trends of these impacts has been a controversial issue since almost three decades ago, when FW became a major item on the developing countries energy agenda. In the 1970s, the *gap* approach [4–7] predicted a severe woodfuel crisis by the year 2000. Massive deforestation and acute woodfuel scarcity situations for some 2.4 billion people were expected as a consequence of the crisis. By the mid-1980s, based on revised assessments and new field data, it was argued that the nature and impacts of the woodfuel crisis had been significantly overestimated, and that there was less of a problem than had been foreseen: woodfuel use seldom posed a serious threat of deforestation and reduced access to woodfuels was fairly easily managed by households through a number of supply and demand substitution possibilities [8,9]. The research conducted during the 1990s,

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including comprehensive field studies and projects, have shown that woodfuels demand and supply patterns are rather complex and very site specific [8–16]. Deficit situations that severely affect woodfuel users and/or negatively impact natural forests vary from place to place [8,9,14,16]. Even in regions with an overall negative woodfuel demand/supply balance, not all the places face woodfuel scarcity, and similarly, regions with an overall positive balance may include deficit areas [8,9,14,16–18].

Interest on potential FW deficits has grown recently due to their contribution to global GHG emissions. Diverse sources [19–21] indicate that the unsustainable harvest and burning of biofuels by the residential sector may account for about 4% of global CO_2 emissions. As with the *gap* approach, these estimates come however from aggregated estimates that do not incorporate the heterogeneity of local situations.

In the need for approaches that help identifying critical areas and focusing resources and/or actions on those places that actually face more acute problems, Masera et al. [3,22] developed the woodfuel integrated supply/demand overview mapping (*WISDOM*). *WISDOM* is a spatial-explicit planning tool for highlighting and determining woodfuel priority areas or woodfuel *hot spots*. To identify these critical areas or *hot spots*, spatial units of analysis at any one scale, are ranked into priority categories, by analyzing relevant interactions over a set of socioeconomic and environmental criteria and indicators, directly or indirectly related to woodfuels supply and demand patterns. Woodfuel *hot spots* can be thus established according to a number of criteria and indicators set by the users. Following a hierarchical analysis through multiple spatial scales, critical areas identified in the first step, can be further analyzed based on more accurate data. In this manner, resources can be used more efficiently and policies can be more effectively directed and tailored to the specific characteristics of the sites. *WISDOM*'s final objective is to assess the sustainable potential use of woodfuels as a renewable and widespread energy source, while supporting strategic planning and policy formulation.

So far, *WISDOM* has been conducted in Slovenia [23], Senegal [24], East Africa [25] and Southeast Asia [26]. Conducting a *WISDOM* analysis involves five main steps (Fig. 1): (1) determining the minimum spatial unit (MSU) of analysis; (2) development of the supply module; (3) development of the demand module; (4) development of the integration module; and (5) selection of the priority areas or woodfuel *hot spots*. For a complete description of the methodology and for more details about its practical implementation, existing databases, and other relevant information please refer to [3,22].

Two main objectives were defined for the Mexico *WISDOM* analysis: (1) Identify at a national scale, FW *hot spots* in terms of residential FW use and availability of FW resources for the year 2000, and (2) estimate net CO_2 emissions from the non-renewable use of FW by the residential sector for the same year. As mentioned above, *hot spots* can be defined according to a number of different criteria and indicators, depending on the objectives of the assessment. In this article, *hot spots* were defined as areas where: (a) insufficient FW resources could be negatively affecting a major number of residential FW users and (b)

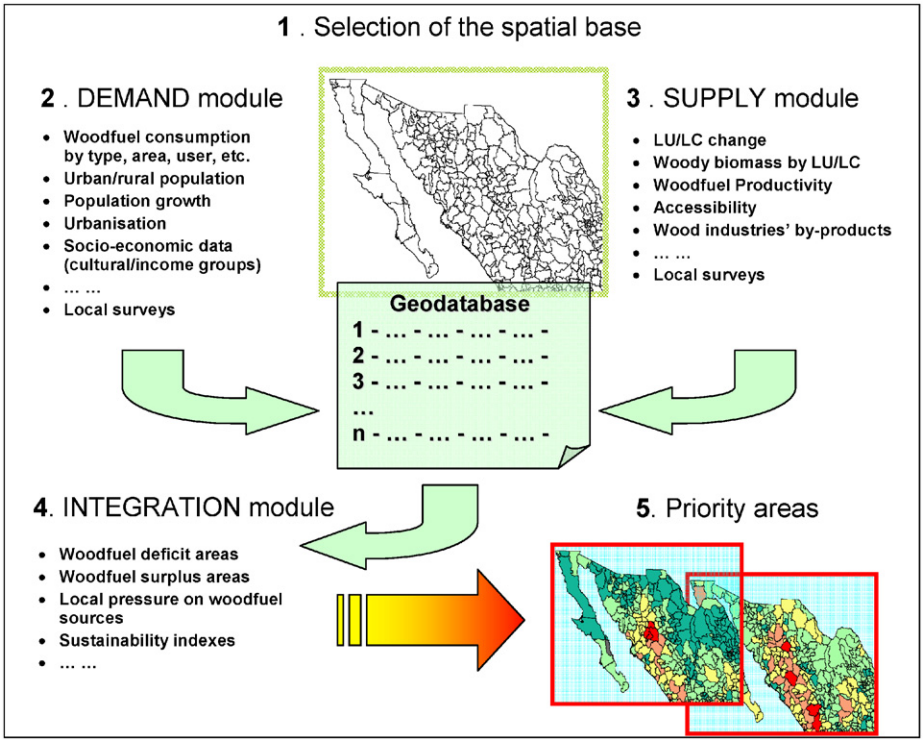

Fig. 1. *WISDOM* steps.