Cost-benefit Analysis with GIS: An Open Source Module for the Forest Bioenergy Sector

Gianluca Grilli a,b*, Giulia Garegnani b, Francesco Geri a, Marco Ciolli a

a Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento (Italy)
b EURAC Research, Institute for renewable Energy, Bolzano (Italy)

Abstract

This paper introduces a novel methodology for the optimal use of forest biomass for energy purposes, by means of GIS procedures. The method allows the identification of the most suitable area for a power plant, starting from the energy demand and the local availability of wood resources. After the site identification, the procedure conducts a cost-benefit analysis, including financial and environmental flows. The described methodology has been automatized in GRASS GIS, which is a free and open source GIS software, and now constitutes a downloadable add-on. In this contribution, we tested such procedure in a case study in Italy, the alpine valleys of Gesso and Vermenagna in Piedmont region (North-West of Italy).

Keywords: cost-benefit analysis; energy power plant; environmental values; renewable energy

1. Introduction

One of the major concerns, when planning the creation of a power plant fueled with biomass, is the economic feasibility of the investment. The energy potential of the local biomass is highly uncertain, as well as the local energy demand. For this reason, an accurate planning of the activities and analysis of the available data is crucial for a successful development of a new power plant. Starting from these consideration, the present contribution proposes...
a novel methodology for estimating the economic feasibility of a new power plant. The procedure takes into account local forest and environmental data to estimate the energy potential harvestable from a certain area. Based on local geographical data and energy consumption density, the positioning and size of the power plant could be further assessed. Finally, a cost-benefit analysis (CBA) is implemented, allowing a comprehensive exploration of the economic convenience of a potential investment, by calculating the net present value of the investment (NPV). CBA may be implemented in several ways and may include social and environmental externalities, which are useful in particular when the potential investor is a public institution [1,2]. In the literature it is possible to find DSS for the estimation of biomass potential [3,4], however most of them do not consider the economic feasibility of the power plant. Our procedure attempts to fill this gap by introducing new tools for CBA. The procedure is part of a set of decision support system (DSS) for energy planning, called “r.green”, realized ad add-ons for GRASS GIS. The procedure has been tested in a case study in the Italian Alps, the Gesso and Vermenagna valleys. We propose three scenarios. In the first one, the hypothetical investor is a private entrepreneurship, thus only financial flows are considered. In the second and third scenario the investor is supposed to be a public institution, which is interested not only to financial aspects but also to social and environmental concerns. In the second scenario we add a measure of the social benefit of a new power plant, which is given by people’s willingness to pay (WTP) for renewable energy. The third scenario adds to the second the environmental impacts, thus even the expected variation of the forest capital is included.

2. Materials and methods

*r.green* is a set of DSS created for the estimation of energy potential from different renewable sources. At the present stage of development, *r.green* includes solar energy, hydropower and forest biomass [5]. The model for the estimation of the forest biomass potential is called *r.green.biomassfor*. The structures of the models are very similar and are organized in several modules. In particular *r.green.biomassfor* has 4 main modules (called theoretical, legal, recommended and economic potential), this paper describes a fifth module (which is called *r.green.biomassfor.plant*), useful for siting the power plant and for CBA. Each module adds some form of constrains and take into account several environmental data in order to refine the estimation [6]. The interested reader may find more information about this suite of GRASS add-ons in [5, 7-10]. The procedure for *r.green.biomassfor.plant* is conducted in two stages. The first step involves the computation of forest and environmental data for estimating the energy potential of the local forested area, the size and siting of the power plant [11, 12]. The second step is the economic analysis.

**Estimating the energy potential.** The environmental analysis involves processing forest data, in order to estimate the energy potential of the considered forest. This part of the analysis is conducted by calling the functions of other *r.green.biomassfor* modules, previously introduced [13].

**Siting power plant.** This part of the analysis is conducted with the new module, “r.green.plant”, and it represent the main novelty of this contribution. Positioning of the power plant is based on the energy demand. The module tries to accomplish the energy demand of a given area by means of a forest biomass power plant. In particular, a raster map with the present level of energy consumption is required. The procedure identifies the pixel with the highest energy demand then, from this point, additional pixel are added to enlarge the area to be served by the plant. The program calculates the average energy demand of the extended area and if it is above a given threshold it continues adding neighboring pixels. The process stops when energy demand is below the threshold, because the investment is considered not feasible. The threshold is set by default at 400 Mwh/ha per year, but it can be modified by the user. Once the area is identified, the size of the power plant is hypothesized, based on the total energy demand of the identified area and the forest biomass availability. In particular, the module computes the total energy demanded by the area and the total potential that may be extracted from the forest. In order to avoid oversizing, the minimum value between energy demand and forest biomass availability is considered. The idea is that the maximum quantity of local forest biomass should be exploited, so the power plant should be as big as possible (until the local demand is satisfied) but not so much to have the need to import biomass from outside.

**Economic Analysis.** This stage is also quite new, because most of the studies in the literature focuses on estimating the energy potential of a given area, with few considerations about new power plants [6,14]. Cost-benefit Analysis (CBA) is an applied economic tool for valuing the economic convenience of a new project. In particular,
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات