Renewable and Sustainable Energy Reviews 29 (2014) 108–119

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

# Extension of energy crops on surplus agricultural lands: A potentially viable option in developing countries while fossil fuel reserves are diminishing

Md. Mizanur Rahman[a,c,*], Suraiya B. Mostafiz[b], Jukka V. Paatero[a], Risto Lahdelma[a]

[a] Department of Energy Technology, Aalto University School of Engineering, FI-0076 Aalto, Finland
[b] Department of Agricultural Sciences, Faculty of Agriculture and Forestry, University of Helsinki, Helsinki FI-00014, Finland
[c] Rural Electrification Board (REB), System Operation Management, Savar, Dhaka 1344, Bangladesh

ARTICLE INFO

*Article history:*
Received 25 March 2013
Received in revised form
22 July 2013
Accepted 25 August 2013

*Keywords:*
Energy crop
Surplus land
Land conversion
Yield improvement

ABSTRACTS

The rapid depletion of fossil fuel reserves and environmental concerns with their combustion necessitate looking for alternative sources for long term sustainability of the world. These concerns also appear serious in developing countries who are striving for rapid economic growth. The net biomass growing potential on the global land surface is 10 times more than the global food, feed, fiber, and energy demands. This study investigates whether the developing countries have sufficient land resource to meet the projected energy demand towards 2035 by planting energy crops on surplus agricultural land after food and feed production. The annual yields of four commonly grown energy crops specifically jatropha, switchgrass, miscanthus, and willow have been used to make scenarios and estimate land requirements against each scenario. This paper first performs literature reviews on the availability of land resource, past and future trends in land use changes, demand of lands for food production, and potential expansion of croplands. The energy demands towards 2035 are compiled from energy scenarios derived by the International Energy Agency (IEA) and the British Petroleum (BP). This paper also reviewed bio-physiological characteristics of these energy crops to determine whether they are cultivable under tropical climatic conditions in developing regions. This paper found that projected energy demand through 2035 in developing regions could be provided by energy crops grown on a portion of surplus croplands or upgraded grasslands (27% and 22% respectively for miscanthus scenario). Sustainable land management practices, improved agricultural productivity, and adopting suitable energy crops cultivation can potentially supply increasing energy demands.



**Contents**



* Corresponding author at: Department of Energy Technology, Aalto University School of Engineering, FI-0076 Aalto, Finland. Tel.: +358 505 709 911; fax: +358 947 023 419.
*E-mail addresses:* mdmizanur.rahman@aalto.fi, mizanur1970@gmail.com (Md.M. Rahman).

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http://dx.doi.org/10.1016/j.rser.2013.08.092

## 1. Introduction

Conventional fossil fuel sources such as oil, coal, and natural gas account for 81% of the global primary energy consumption in 2010 [1]. The recoverable proven reserves of these fossil sources are projected to be diminished by about 40 years, 55 years, and 130 years from now at the current rate of use for oil, natural gas, and coal respectively [2]. This projection shows that the proven fossil fuel reserves will be completely exhausted after 70 years at the current rate of consumption, and most likely earlier considering the increasing trends of demands [3]. The current pattern of energy supply cannot be sustained in the near future because of the depletion of fuel reserves and also environmental impacts of using these fuels [4]. The surging demand of food, feed and energy for the increasing global population is provoking the earth's ecosystem and its limited resources [5]. The negative environmental consequences and declining fossil fuel reserves have increased interest in renewable bioenergy sources.

Bioenergy is a renewable source of energy, and its sustainable use emits net zero $CO_2$ to the atmosphere. The increasing use of this energy source could reduce the GHG (greenhouse gas) emissions and contribute to achieve the sustainable development goals [6]. The major inputs into bioenergy production are land and water resources, which are also essential for producing food, feed and other essential plant commodities. The competitive feature of resources for biomass puts bioenergy under scrutiny before determining their real potential which is sustainable. On the one hand, biomass for energy production is an attractive substitute for fossil fuel sources, and on the other hand, its competing application of lands and water resources poses doubt on its potential.

One study [3] finds that the global energy demand projected by the IEA (International Energy Agency) in the reference scenario[1] for the year 2030 could be provided from the lignocellulosic bioenergy crops grown sustainably on unarable degraded lands. This study claims that the land and other resources would not compete with the increasing food production. They say that the energy demand can be met through afforestation of degraded areas, and investment for energy from biomass is cheaper than investing in fossil based energy. Another study [5] finds that the maximum primary energy potential from biomass in 2050 is 161 EJ/yr on projected surplus cropland and land extended from grassing areas. Smeets et al. [7] estimated that bioenergy potential on surplus agricultural land (i.e. land not needed for food, feed etc production) equaled 215–1272 EJ/yr, depending on the advancement of agricultural technology. Hoogwijk et al. [8] estimated that energy potential from energy crops on surplus agricultural land is as much as 998 EJ/yr. Another study [9] says, the global potential for bioenergy production ranges from 130 to 410 EJ/yr on abandoned degraded land. The potential of biomass energy depends primarily (besides other factors) on land availability. Currently the land area utilized for growing energy crops for biomass fuel is only 0.5–1.7% of global agricultural land [10]. Study also suggests that only 10% increase in biomass production through irrigation, manuring, fertilizing, and/or improved management in land use could serve the entire global primary energy demand. In the regional scale, one study [11] reveals that the biomass potential in the European Union region is sufficient enough to ensure the bioenergy target by 2020; however, mobilization of biomass plantation would be the key challenge. IPCC (Intergovernmental Panel on Climate Change) special report on renewable energy [12] suggested that, in 2050, the bioenergy potential can be in the range of 50 EJ/yr in the scenario of high food and fiber demand, and reduced agricultural productivity, to about 500 EJ/yr by maintaining key sustainability criteria.

Several studies have estimated the sustainable biomass potential for bioenergy production in global scale and in-line with various scenario and assumptions; however, far too little attention has been paid on bioenergy potential in developing countries. In this study, we examine the extents of land availability for meeting the projected energy demand in 2035 in developing countries through selected energy crops scenario grown on surplus croplands or lands upgraded from pasturelands or grasslands. We review literature for land availability, their current and projected uses, and historical changing trends. We also review the bio-physiological characteristics of four energy crops to see whether they are suitable to grow under tropical climate conditions in the developing countries. Based on the insight gained from the literature review, we made a set of assumptions on which we determine the extents of surplus land availability for meeting the projected demands. This article also highlights the sustainability issues related to bioenergy production concerning economic, social and environmental impacts on them. Land management practices, increasing of productivity, and reconciliation of land and water sharing would be the main challenges to realize the potential.

## 2. Materials and methods

In the first part, relevant literature were reviewed to explore the current status on land availability, land use pattern, crops and energy production and their present and projected demands. Historical trends in land use changes, crop yields, per capita land use were also reviewed from statistical database and literature sources. In the second part, a set of assumptions were made based on the information and insight gained from the reviewed literature to determine the extents of land availability for growing selected energy crops to meet the projected demands. Characteristics of four commonly used energy crops are reviewed for examining their adaptation suitability in developing regions, which are mostly fallen under tropical climate zones. Developing regions are selected as those geographic areas which are classified as developing economic zones according to United Nations Statistics Division (UNSD) [13].

### 2.1. *Review of literature*

#### 2.1.1. *Land availability on the global scale*

Total land surface of the globe is 13.2 Gha, and among them 5.0 Gha has been in use for food production for direct human consumption and animal grazing for livestock [14]. FAO classified the total land area into four major land-use categories: arable land, permanent meadows and pastures (grasslands), forest area, and other

[1] Reference scenario took into consideration only those policies and measures that had been formally adopted by mid-of the studied year (2006).