Renewable and Sustainable Energy Reviews 50 (2015) 903–917

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

Sustainable use of organic resources for bioenergy, food and water provision in rural Sub-Saharan Africa

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ARTICLE INFO

Article history:
Received 15 December 2014
Received in revised form
10 March 2015
Accepted 23 April 2015
Available online 2 June 2015

Keywords:
Biogas
Pyrolysis
Composting
People-centered discourse approaches
Local and national governance
Sustainable organic waste practices

ABSTRACT

This paper reviews use of organic resources in rural Sub-Saharan Africa (SSA), impacts on household energy, and interactions with provision of food and water. Wood, charcoal and dung supply over 70% of household energy in SSA, but with improvements in energy technologies, crop-residues and human excreta could also contribute. Improving cookstoves is not enough to make woodfuel use sustainable, reducing deforestation due to woodfuel demand by only 41–50%. Further reductions of 21% are achieved by using crop-residues and 23% by anaerobic digestion of cattle manure. Taken together, these measures could reduce deforestation due to woodfuel demand by 70–100%. Burning crop-residues loses a large proportion of nitrogen needed for crop production, which could be partially counteracted by applying biochar from pyrolysis cookstoves to improve retention of soil nitrogen. Better nutrient recycling would be achieved by composting, but this precludes energy provision. Both energy and efficient nutrient recycling are provided by anaerobic digestion, but carbon sequestration is reduced compared to composting or pyrolysis. Nevertheless, a wider range of waste materials may be recycled in the closed digester system, so pyrolysis of dry crop-residues together with anaerobic digestion of wet wastes is likely to provide the best solution for both food and energy. However, anaerobic digestion may demand more water than pyrolysis and, if soil carbon is reduced, may also increase the need for irrigation. Therefore, in water limited areas, biogas digesters should only be installed if integrated with water harvesting systems. Governments can encourage adoption of sustainable technologies by providing subsidies to cover fixed costs, facilitating credit and complementary infrastructure investments, and improving standardisation and quality control in cookstove and digester markets. Implementation work should involve communities and households, giving women a role in decision-making to ensure community investment in water access.

Contents

Abbreviations: SSA, Sub-Saharan Africa

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http://dx.doi.org/10.1016/j.rser.2015.04.071
1364-0321/

1. Introduction

1.1. Problem statement

This paper considers the use of organic resources in rural areas of Sub-Saharan Africa (SSA), their impact on basic human requirements for energy, food and water, and how organic resource use can be made more sustainable. Organic "wastes", include crop-residues, food waste and excreta, and are of such value that many authors refer to them as organic "resources". Here we refer to residues from other processes as "organic wastes", and distinguish them from organic resources that have been grown or collected specifically for their primary use. This distinction is important, as it means that organic wastes represent a pool of resources that might not otherwise be used. Finding new ways of using them can help deliver the Millennium Development goals relating to poverty alleviation and environmental sustainability by extending access to clean energy and water and increasing sustainable agricultural production.

Globally, over 2.8 billion people still rely on unsustainable solid biomass for cooking and heating fuel, of which ~2.2 billion (78%) live in rural areas. Communities in isolated rural areas often represent the poorest segment of the population in developing countries [1]. In countries without access to fossil fuels, organic resources provide a key source of energy. Wood, charcoal and dung are traditional biomass fuels that supply over 70% of the household energy in SSA [2]. Organic wastes provide alternative energy sources for cooking and lighting, either by direct burning of dried materials, or by anaerobic digestion to provide biogas [3].

The use of organic resources for energy directly impacts food production. Woodfuel use can cause localised deforestation, making more land available for agricultural production, but can also result in long-term loss of soil fertility and reduction in local rainfall [4]. Burning organic wastes removes carbon and nutrients from the agronomic system, whereas the residues from anaerobic digestion are rich in available nutrients, so providing farmers with a valuable organic fertiliser that can be used to improve yields [5,6].

Organic resource use also affects water availability. Water quality can be improved by using organic wastes in energy production, so removing pathogens from the wider environment [7]. Burning of organic resources requires no extra water, whereas anaerobic digestion requires extra water to mix wastes into a slurry, and so impacts the quantity of water required by a household each day [3].

The best technical use of organic wastes depends on the availability of resources and requirements for food, energy and water, but there are also economic, social and cultural factors affecting adoption. At household level, organic waste practices, such as the purchase and use of a biogas digester, implies a range of changes; new capital expenditure may increase credit demand and change the household exposure to risk, but reduced expenditure on fuel may reduce weekly outgoings [8]. Social and gender relations within households and communities can also be affected; adoption of new technologies changes labour requirements for water and wood collection and for livestock management, so affecting both the total amount of labour and its allocation across family members [9].

In this paper, we consider the best technical use of organic wastes and how economic, social and cultural factors and social norms influence uptake. We examine the impact of adoption on agricultural productivity, energy provision and water use in poor rural households of SSA, and the role of social and economic forces. We review current policy issues and governance arrangements and consider what further changes are required to achieve sustainable solutions. Finally, we identify areas where evidence and understanding is lacking and prioritise future research goals.

1.2. What are sustainable organic waste practices?

Sustainability has been interpreted in different ways across and within disciplines. Within environment and development studies, sustainable development looks at the interaction between the economic, environmental and social spheres and how these impact on human development [10]. Within economics, definitions range from strong sustainability [11], where the need to conserve individual elements of natural capital are emphasised, to weak sustainability [12] where substitution of natural and other capital is emphasised and a sustainable environment merely maintains overall productive capacity. By this definition, strong sustainable organic waste practices require all dimensions of natural capital stock (forests, water and soil) to be conserved to provide a sustainable yield of wood, water and food for future users. By contrast, weak sustainable organic waste practices would allow degradation of individual resources if overall future production is maintained.

1.3. International and national support for sustainable organic waste practices

The potential environmental, health and economic benefits associated with sustainable organic resource use has led to a significant effort by governments in SSA, supported by national and international