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Sustainable Livelihoods in the Green Economy

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Karelia University of Applied Sciences
julkaisut@karelia.fi
http://www.tahtijulkaisut.net

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Contents

Foreword: Added Value from International In-depth Co-operation

Internationalisation of education is one of the key development goals among higher education institutes around the world. And not just any kind of internationalisation; actions need to be strategic and systemic supporting the organisations' long-term development plans as well as regional, national and international education policies. Shared commitment, needs, willingness and responsibility in international partnerships are crucial to enable successful implementation of the actions. Moreover, the student and teacher competence development need to be embedded into the implementation. When internationalisation of education is approached in such a holistic way, results may bring remarkable added value to the network both on organisational and individual levels.

The network co-operation under the North-South-South programme has proved to be an example of successful international co-operation which brings added value to students, teachers and participating organisations. This added value is a combination of learning, new skills, widened perspective of one's professional field and professional networks. But besides these, the co-operation has brought experiences that will be remembered for the rest of the life time. In international co-operation not only the learning in the official context matters, it is also highly important to experience personal highlights, make friends and enjoy the new surroundings.

The actions of this North-South-South co-operation have covered teacher and student mobility, curriculum development, intensive courses, capacity building, knowledge transfer, teacher and student competence building as well as small-scale research co-operation. During its long history, the network co-operation has enabled varied operations supporting development processes in each of the partner universities. For example, the intensive courses have offered an excellent opportunity to gain added value on official and non-official levels. Furthermore, they have had an impact on curriculum development by bringing new perspectives on the issues discussed on the courses. While meeting and developing things together, teachers and students learn a lot – they gain professional and holistic international competence which is a valuable asset in their future career paths.

One aim of the North-South-South programme has been to strongly support development actions, capacity building and networks in and between the Southern partners. As a consequence, the partners from the South have had an opportunity to share their expertise and some results of their research actions with the whole network and wider audience.

With this publication we want to make some of our North-South-South network results and core topics of interest visible. In the beginning of the journal we also give a short review on the network history as well as student and teacher experiences. Take a journey with us and enjoy the reading!

Dr. Liisa Timonen
Head of International Affairs, Karelia University of Applied Sciences

Preface

This publication is a collection of articles based on the topics from two intensive courses of the North-South-South Zambezi and Zambezi II networks, held in Kitwe, Zambia (2012) and in Katima Mulilo, Namibia (2014). The topics of the courses revolved around environmental issues relevant to all actors in the agricultural and forestry sector. The articles have been written by lecturers in different fields of natural resources and from different organisations participating in the network.

The aim of the publication is to disseminate information generated during the network activities to a wider audience. The articles present current solutions and procedures in the participating countries on how and why environmental issues can be taken into account in agricultural and forest related practices. The articles are written from a country perspective to provide the readers with different viewpoints than in their own home country. Some economical aspects and possibilities for income generation especially in the rural areas are also introduced.

The book is arranged in three chapters. The greening of the rural economies through integrated water resources managements, green manuring and oyster mushroom production is presented in chapter one. Chapter two deals with partner perspectives on sustainable agriculture and livelihood through agriculture systems, conservation techniques and use of waste water in urban agriculture. Sustainable natural resource management and utilization is presented in chapter three and includes gender and natural resource management, renewable energy production and associated environmental impacts.

The network consisted of four partners in Zambezi during 2011-2013. The partners were Karelia University of Applied Sciences (formerly North Karelia University of Applied Sciences, Finland), University of Namibia (Ogongo Campus), Botswana College of Agriculture and Copperbelt University (Zambia). For Zambezi II implemented 2013-2015, the network included additional members from Mulungushi University (Zambia) and Oulu University of Applied Sciences (Finland).

The network has been funded by the Ministry of Foreign Affairs of Finland under the North-South-South Higher Education Institution Network Programme, administered by the Centre for International Mobility CIMO.

NORTH-SOUTH-SOUTH
Higher Education Institution Network Programme

Chapter 1.
Greening the Rural Economy

History, Goals and Experiences of the North-South-South Network

Kaija Saramäki and Katriina Korhonen
Karelia University of Applied Sciences, Finland

1. Introduction

The North-South and North-South-South (NSS) higher education institution network programmes (2004 – 2015) initiated by the Ministry for Foreign Affairs of Finland and Centre for International Mobility (CIMO) have funded thematic networks between higher education institutions in Finland and in developing countries. The name of the programme was changed to North-South-South in 2007 to stress the need and significance of South-South cooperation in striving for the desired development goals.

The goals of the North-South-South programme, set by the Ministry for Foreign Affairs of Finland have included

- enhancing human capacity to ensure that people in all participating countries may better contribute to the cultural, socio-economic and political development of their communities,
- establishing long-term links between higher education institutions,
- raising quality of education by sharing skills and information, and
- supporting UN Millennium Development Goals and Finnish Development Policy.

In addition, each network set its own objectives to contribute towards these overall goals.

The programme's 10-year-history is highlighted in the recent publication: North-South-South 10 Years: A Decade of Supporting Development through Academic Mobility: http://www.cimo.fi/services/publications/north_south_south_10_years.

2. The network organisation

Karelia University of Applied Sciences (formerly North Karelia Polytechnic / North Karelia University of Applied Sciences) acted as a network coordinator since 2005 in five consequent funding periods in projects called Omusati, Omusati II, Zambezi and Zambezi II. The network evolved from inclusion of one partner from Finland and one partner from Namibia to a multinational and cross-sectoral cooperation network within several higher education institutions.

In the course of time, the variety of activities funded by the NSS programme increased from student and teacher exchanges to network activities (administrative visits and network meetings), intensive courses and dissemination measures.

The focus of funding was in exchanges and intensive courses. The network hosted 60 student exchanges and 52 teacher exchanges in 10 years. Total of 107 students and 41 staff members participated in three intensive courses which truly brought the partners together to plan, organise and implement programmes that dealt with topics of key relevance to the network. For many partner institutions, the intensive courses were perhaps the most dynamic, effective and interesting type of activity that provided a great platform for participants from different institutions to learn together, network and create contacts for future career and personal life.

Figure 1. Students presenting pre-tasks during the first intensive course in Kasane, Botswana, 2009. Photo by Katriina Korhonen.

The southern partners in Zambia and Botswana also organised dissemination activities building on the experiences and material of the network, especially the intensive courses.

Table 1. Summary of network activities

Implemented activities during the 5 phases of the network Funding (total) € 485 094		
Student exchanges 60	North to South 22	South to North 38
Teacher exchanges 49	North to South 25	South to North 27
Administrative visits 6	6 from South to North	
Network meetings 4	Ogongo 2008, Gaborone 2011 & 2013, Lusaka 2015	
Intensive Courses 3	"Sustanainable Natural Resource Management Plan, Case Kasane", Kasane, Botswana, August 2009 Intensive Course on Renewable Energies, Kitwe, Zambia, Feb-March 2012 "Green economy for sustainable rural livelihoods through integrated management of agricultural and forest waste", Katima Mulilo, Namibia, March 2014	
Dissemination measures 2	By Copperbelt University and Mulungushi University, Zambia, October 2015; Botswana College of Agriculture, November 2015	

The goals set for the Zambezi and Zambezi II networks were:

"The partner countries' regions will have access to cleaner water, sustainably produced energy and their overall knowledge of issues regarding natural resource management will improve." (Zambezi)

"The partner countries' regions will have access to a cleaner environment and the capacity to care for the natural resources sustainably." (Zambezi II)

The purposes were set as:

"Capacity building" (Zambezi)

"The partner organisations will have the capacity to transfer knowledge on and means for sustainable use and further processing of natural resources for income generation to their students and to the communities in which they operate." (Zambezi II)

The network objectives (expected results) were not only addressing issues of academic performance, acquiring credit points or such, but they also called for personal and professional growth, something the students and lectures would have within them for the rest of their lives. Therefore for the Zambezi and Zambezi II the objectives, in short, included:

Institutional objectives

- Increased capacity to offer courses in new and needed areas
- New teaching aids and methods

Individual objectives

- The students will grow to be confident and active members of the society
- The students show appreciation and understanding of different cultures
- The students' problem-solving skills will improve
- Students are aware of new learning methods and aids
- The students will have a broader perception of educational systems
- Wider network of students and lecturers from different parts of the world
- Improved cooperation skills
- Improved planning and organizational skills

3. Student exchanges and experiences

Student exchanges from the North to the South and the South to the North have proven to be efficient in terms of the students' personal capacity building, cultural exposure and personal growth. The cultural understanding gained during the exchange periods is invaluable to the student's further studies and career as well as their everyday life. The student feedback shows that this is the single most important thing they have learnt or gained from their exchanges. A number of students expressed this in their feedback as follows:

"It's taught me how to live in a multicultural group" (female student, Zambia)

...I have also become more independent, more confident in myself and I have learnt not to judge things by their first impression which I did not essentially do before the exchange. (female student, Zambia)

Personal growth, not fearing of failure, more relaxed attitude, understanding that problems of the north are often small. (female student, Finland)

I now feel comfortable approaching strangers and find it easy to form new friendships. I am no longer as anxious or shy about meeting new people. (female student, Namibia)

Figure 2. Students during field trip in Katima Mulilo, Namibia, March 2014. Photo by Kaija Saramäki.

The experiences of the students have mainly been positive with only a few hick ups during or after the exchange. Mainly the impacts have been positive and include getting to know new teaching methods, report writing, referencing and presentation skills. The exchanges have affected the students' further professional lives and improved their employability and professional skills.

The exchange has affected me in so many ways especially in the work culture and reasoning ... I combined the knowledge I gained towards my academic excellence (male student, Zambia)

Exchange gave me more motivation and taught me the importance of education... it made a major difference in my life (male student, Namibia)

Education system that side was practical oriented thus I can still remember most of the things I learned there (female student, Namibia)

Also it's made me less afraid of teacher-student interaction (female student, Zambia)

I'm currently an intern at United Nations Development Programme-Namibia country office, under Energy and Environment unit. I was given this chance simply because I have an understanding of global environmental concerns. (female student, Namibia)

The labour market demands people with language skills and multicultural understanding with strive for success and widening their competences. (female student, Finland)

I have been able to apply the knowledge and skills obtained from such courses as; sustainable development, bioenergy technologies and project management to mention just a few. (male student, Zambia)

The capacity built has helped me to work in government under the Ministry of Energy as an Energy Officer in the Renewable Energy Unit. (male student, Zambia)

Figure 3. Zambezi Intensive course on renewable energies, Kitwe, Zambia, February-March 2012.

Since the networks have been running since 2005 many of the exchange students have graduated. After graduation the students have, for example, continued studies in the master level, started working or continued studies in another field. The knowledge and experiences from the exchanges have been put into active use in these.

I have applied time management learned, effectively and efficiently duties allocated (female student, Botswana)

Pollution control was another module which is more influential since I am doing Master in environmental science now and most of my modules are related to pollution control. (female student, Namibia)

Further, I give technical advise on maximum utilisation of forest resources to produce energy such as the utilisation of branches that are left during tree felling for the production of briquets. (male student, Zambia)

I will use the knowledge I have acquired here to help develop my country. One target is to improve the waste management system of my home country this is all because of the knowledge I have acquired from the project I was doing here looking at waste management system of Finland, Oulu, to be specific. (male student, Zambia)

4. Lecturer exchanges and participation of staff in the activities

The lecturer exchanges were part of the network activities since the beginning. They were planned, where possible, to combine lecturer exchange with intensive courses or with network meetings or other coinciding activities in the destination. Most often the lecturers participated in lecturing, field visits, attending other lecturers classes, industrial visits and meetings with students and staff. The aim was always to bring lecturers from different southern partners to come on exchange to Finland and at the same time to contribute to the South-South collaboration, which otherwise has had a lesser role in the network.

The effects of participation in the network activities are positive to the staff both personally and professionally. The lecturers have gained experience and learnt new teaching methods. Cultural and social experiences have been mentioned in many feedback messages as a major benefit of the exchanges along with the ability to cope in different settings, environments and climates. This has increased the lecturers' understanding of different environmental issues in other countries and introduced new technologies and methods for cultivation, forest management, project management, etc.

5. Impact of the network activities

The partners have appreciated the added value of information and knowledge exchange in education, research, organisation cultures and everyday life of the participating countries. Long term exchanges and intensive courses have been regarded as especially useful.

The world view and awareness of the students and teachers in regard to various academic, professional, cultural and administrative aspects has been widened. The project has enhanced the capacity of project participants as well as participating institutions as a whole to work in international projects and multicultural contexts. In addition, there is a wider awareness and understanding of development issues. In the long run, the participation of the teachers and students in the project activities can contribute to national development and poverty reduction through capacity building achieved during the network activities.

The organisational benefits also include a deeper understanding of different educational systems including e.g. learning philosophies, crediting systems and curriculum development and revision. The higher education institutions have gained valuable experience in hosting foreign students and staff members. The individual beneficiaries of the network activities include not only the ones who had the opportunity to go abroad but also the students and staff who stayed at home but were exposed to encounters with incoming teachers and students representing very different cultural backgrounds.

Because of the network, there are now good working relations between all the participating institutions. Bilateral memorandums of understanding provide a framework for future cooperation in exchange, research and development activities.

Integrated Water Resources Management and Environmental Protection in Watersheds

Joseph T. Mwale
Mulungushi University, Zambia, School of Agriculture and Natural Resources

1. Introduction

The United Nations Environment Programme (2012, 2) defines a green economy as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. The practical implication of this definition for rural development is greening agricultural production in rural areas through the use of sustainable farming methods. This paper is focused on the application of the integrated approach to greening the rural economy through water resources management and environmental protection. It is premised on the social-ecological perspective of environmental degradation, which is an outcome of the interactions between the human land uses and natural systems.

2. A social-ecological perspective of environmental degradation

Environmental degradation generally refers to the long-term reduction in the quantity and quality of environmental resources. The discourse on environmental degradation in this paper is guided by the broad theoretical perspective of Social-Ecological Systems Analysis. A Social-Ecological System (SES) refers to a coupled human and natural system comprising the resource system, resource units, governance system and users (Folke 2006, 261). It is a complex system delimited by spatial or functional boundaries surrounding particular ecosystems. Of major interest to scholars is what patterns of interactions and outcomes are likely to result from using a particular resource system in a specific technological, socio-economic and political environment; and how robust and sustainable is a particular configuration of users, resource system, resource units and governance system to external and internal disturbances (Ostrom and Cox 2007, 6).

With regards to rural livelihoods, the nexus between poverty and the environment in rural areas has notable implications for applied research, policy and development practice. Most research revolves around the downward spiral of poverty and environmental degradation (Scherr 2000, 481). According to this model, the use of unsustainable land use practices by poor people stresses the natural resource base beyond its productive capacity, which results in environmental degradation and a shortage of arable land and water resources. The social-ecological outcome of this natural resource degradation is a vicious cycle of poverty and environmental resource scarcity. Kachali (2007, 13) illustrated the vicious cycle of environmental degradation and poverty in a wetland ecosystem in Zambia using a Causal Loop Diagram (CLD) shown in Figure 1.

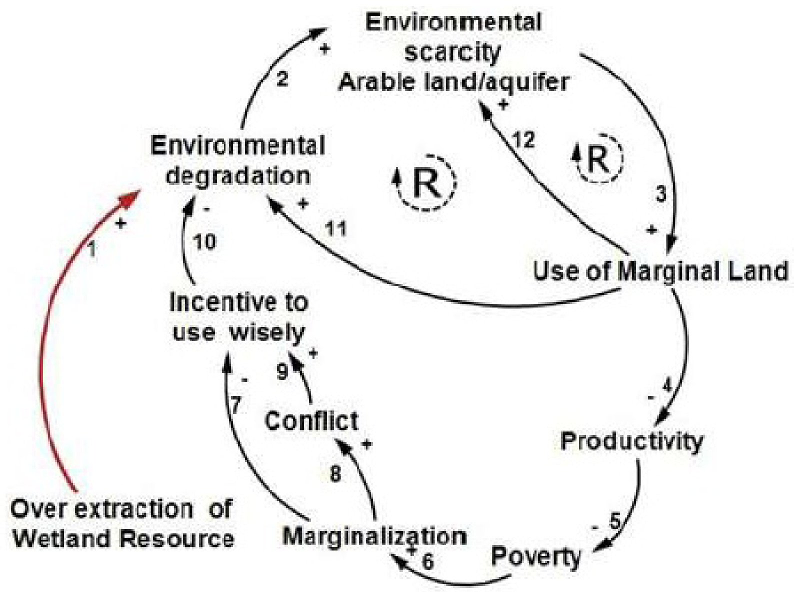

Figure 1: Causal relationship between poverty and environmental degradation in an ecosystem (Source: Kachali 2007, 13)

The CLD shows that the over extraction of resources (line 1) leads to environmental degradation, which results (line 2) in environmental resource scarcity and the use of marginal resources (line 3). As the use of marginal resources increases, productivity drops (line 4) leading to increased poverty (line 5). Poverty marginalizes the community (line 6), which lessens the incentive to use environmental resources wisely (line 7) and also causes conflict among stakeholders (line 8) that further reduces the wise use of resources (line 9). This ultimately reinforces environmental degradation, use of marginal land and environmental scarcity (lines 10, 11 and 12). According to Kachali (2007, 13), this system continually reinforces itself until a management strategy is put in place that takes into account all stakeholders to deal with inequitable resource allocation and conflict. This predicates an integrated approach, which is recognised and highlighted in this paper.

3. The integrated water resources management (IWRM) approach

The integrated approach is a renewed paradigm to solving complex challenges, which cannot be effectively tackled using sectorial approaches. The rationale of integrated approaches to environmental management is providing understanding of the finite and vulnerable characteristics of the prime natural resources, and ensuring that natural resources are managed on a sustainable basis to provide for the environmental, social and economic well-being of the stakeholders. In water resources management, the integrated approach recognises that although water is a renewable resource, it is a fugitive resource with variations in stock and flow, and is vulnerable and subtractible in use. Thus, the core principles of economic efficiency, equity and ecological sustainability should be embraced in water resources management. Furthermore, the integrated approach promotes the legitimate involvement of stakeholders in decision making through dialogue. The stakeholder dialogue process helps to reconcile divergent needs of stakeholders by raising the awareness of the interlinked nature of resources systems.

Operationalizing the IWRM approach is in itself a challenge. This is where the spatial dimension of environment management is very important. For example, the IWRM approach considers the use of a watershed scale. A watershed is an area that contributes water from a topographic boundary to a convergence point. It is delineated by its outlet or convergence point and the surrounding drainage divides. Within the topographic boundary of a watershed system (Figure 2), environmental resources such as the soils, landforms and vegetation interact with human land uses in complex ways.

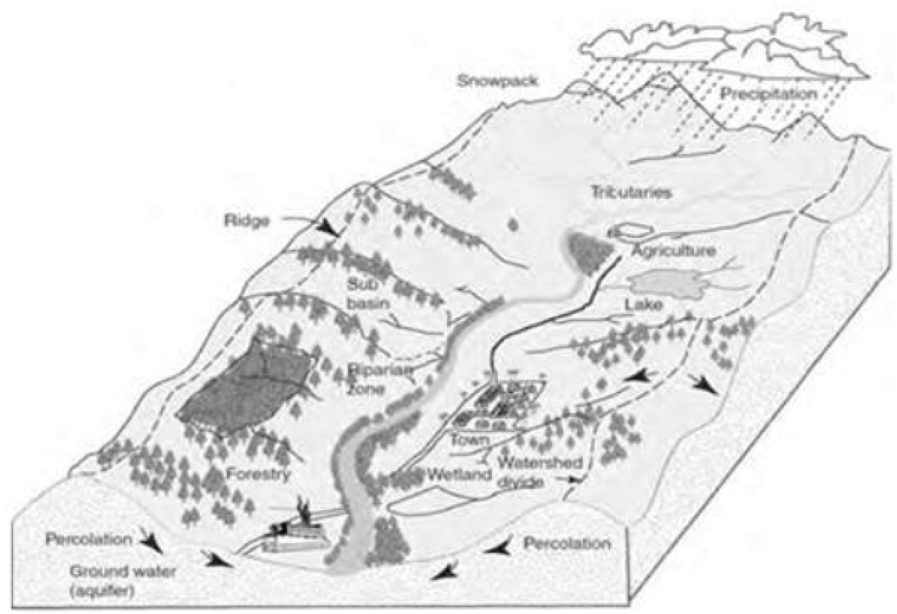

Figure 2: A watershed system (Source: USEPA, 2005)

4. Environmental protection in agricultural land use in watersheds

Agricultural land uses affect the water environment adversely, particularly from nonpoint-source runoff, hazardous-waste disposal and habitat destruction. Several poor agricultural practices contribute to natural resource degradation in watersheds. Examples include such practices as uncontrolled deforestation, shifting cultivation without adequate fallow periods, overgrazing, cultivating in riparian zones, over pumping groundwater, over fertilisation, inappropriate cropping patterns, draining of wetlands and discharge of pollutants into water bodies.

In view of the foregoing, environmental protection in agricultural watersheds consists of bringing into focus the cumulative effects of natural resource degradation, and translating this understanding into best management practices. As such best management practices include integrated pest management, integrated nutrient management, low-tillage farming, agro-forestry, aquaculture, water harvesting, livestock integration and nitrogen-fixing crops. These practices have been seen to contribute to increasing food availability and reducing poverty among the largely marginalised rural communities.

5. Concluding remarks

Greening the rural economy entails putting into action the best management practices aimed at offsetting the negative consequences of the unsustainable use of environmental resources. The social-ecological outcome of the interactions between the human and natural systems in a rural economy is a vicious cycle of environmental degradation and poverty. This calls for management approaches that ensure sustainable rural livelihoods. Integrated approaches such as integrated water resources management ensure that natural resources are managed on a sustainable basis to provide for the environmental, social and economic well-being of all stakeholders. The role of science in this is bringing into focus evidence of the cumulative effects of natural resource degradation and the policy measures that will address the negative externalities of environmental resources utilisation.

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Green Manuring - A Review

Exilda Chisha–Kasumu and Donald Zulu
Copperbelt University, Zambia, School of Natural Resources,
Department of Plant and Environmental Science

1. Introduction

Soil nutrient status can be enhanced by using organic matter in the form of plant waste (leaves; twigs; lawn clippings), compost, animal waste and green manures. In green manuring, the green (fresh) biomass is incorporated into the soil unlike in mulching, where the biomass/or mulch material is left on top of the soil for the purpose of covering the soil/ground in order to protect it against effects of rainfall, wind and sun (Bot and Benite 2005). ADAS (2006) described fresh organic matter as "providing nutrients particularly Nitrogen (N) and Phosphorous (P) benefiting soil physical conditions and biological activity".

Some of the tree species used in the provision of green manure and which have nitrogen fixing abilities are: *Gliricidia sepium, Leucaena leucocphala, Faidherbia albida* and *Moringa oleifera* to mention a few. It is worth noting that the source, quality (ADAS 2006) and type of biomass for these manures matter a lot, as mineralisation rates and availability of nutrients is affected by the type of plant species.

Green manures once applied to the soil correctly may provide many advantages in form of soil nutrient enhancement by nitrogen fixation and soil conservation. Due to improved soil conditions crop yields increase thereby improving the lives of many users/farmers. On the other hand, in the process of using green manures, disadvantages may be experienced in the form of negative effects of allelochemicals on plant growth. There is also a danger of plants grown for the provision of green manures being alternate hosts to pests and diseases and being invasive if not well chosen. This chapter reviews green manuring using biomass for nutrient provision, what they are, sources, advantages and disadvantages.

2. Green manure plants

Green manure material can come from legume and non-legume sources which maybe of agricultural or tree crop origin. Examples of some of the agricultural crops that can fix atmospheric nitrogen are; clover, pigeon pea (*Cajanus cajan*), velvet bean (*Mucuna pruriens*), cowpea (*Vigna unguiculata*), kidney bean (*Phaseolus vulgaris*), and groundnuts (*Arachis hypogaea*). Tree species that can fix atmospheric nitrogen and mostly used for green manuring are those used in agroforestry, namely: *Gliricidia sepium, Moringa oleifera, Calliandra calothyrsus, Sesbania sesban, Leucaena leucocephala, Cassia siamea, Faidhebia albida*, and *Tephrosia vogelii*, to mention a few. Leguminous crop material is most preferred for green manuring as it is readily degradable with low C: N ratios, favouring decomposition (Bot and Benites 2005). Legume plants are also able to fix atmospheric nitrogen (Rayns and Rosenfeld 2010). ADAS (2006) described atmospheric nitrogen fixing plants, "as generally accumulating more organic matter than those that do not". It is also worth noting that some non-legume plants, for example, grazing rye or mustard, may add as much total N to the soil as legumes although their nitrate availability is slower (Rayns and Rosenfeld 2010).

3. Nitrogen fixation process

Two types of green manure crops exist as those that can 1) capture N through the root system preventing it from being leached and 2) fix atmospheric N (ADAS 2006: Fig. 1). It is made possible for plants to convert atmospheric N (N_2) into ammonia (NH_4) due to bacteria called Rhizobia found in the root nodules or maybe free living. The conversion occurs through a process called nitrogen fixation (Rayns and Rosenfeld 2010; the Government of Manitoba 2013). The bacterial group termed *actinomycetes* or and *Rhizobia* belongs to the genus *Frankia* (Lawton et al. 2015). Lawton et al. (2015) described, "other types of bacteria that transform NH_4 to nitrate and nitrate to N_2 or other N gases".

The nutrients tapped by the plant are stored in the mass as carbon, and when shed off the tree decompose or mineralise to release nutrients to the soil (Fig. 1). More N is fixed to the soil through root parts and nodules upon decomposition.

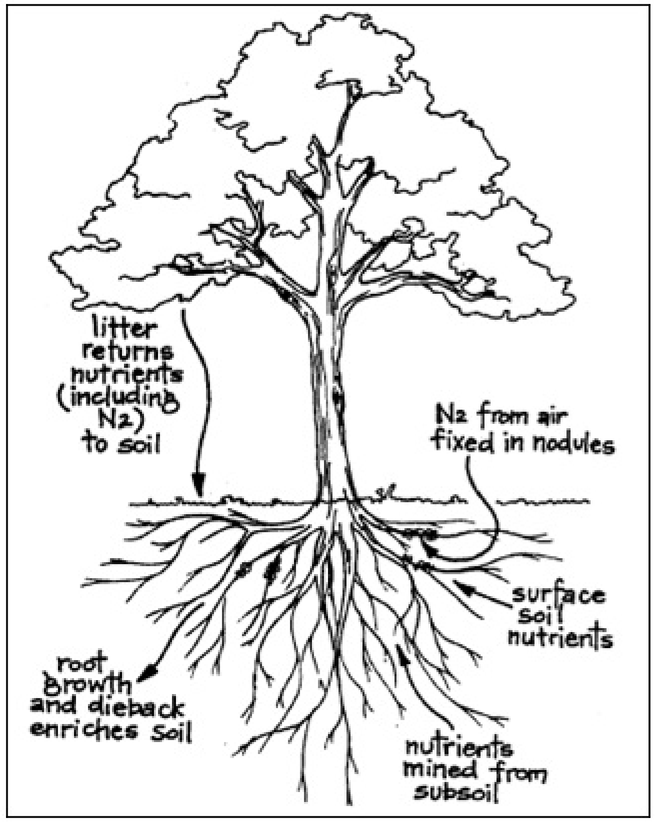

Figure 1. Different sources of nutrients to the plant and the soil. Source: Lawton et al. (2015).

4. Effect of organic material

The effect of organic material in improving the nutrient soil status will differ considerably depending on the source, quality of biomass and the species being used. The differences in the effect of the biomass on nutrient release will depend on decomposition rates, amount, quality, concentration, and also the rate and patterns of nutrient release. The chemical composition of the biomass in use will also determine the impact on soil nutrient status (Rayns and Rosenfeld 2010). However, Bot and Benites (2005) stated that, "the speed of biomass decomposition depended on the soil biological activities, presence of soil organisms, the soil physical environment, soil properties such as texture, pH, temperature, moisture, aeration and clay mineralogy". Good soils coupled with high quality biomass will yield better results than application on poor soils that may require amendment with lime. On the other hand, it is important to apply the green biomass at the right time avoiding the dry periods, or else watering is required to assist in decomposition (ADAS 2006). It is also worth noting that the amount of carbon contained in the biomass will affect the rate of nutrient release. The carbon can be in different forms; for example, lignin is more resistant to decomposition than cellulose, and some plants contain chemicals (e.g. polyphenols) which can inhibit microbial action (Rayns and Rosenfeld

2010). It is important to know the positive and negative interactions the added biomass will have on the soil and the crop given manure, as compounds, such as allelochemicals, e.g. polyphenolics, may be present in the biomass and negatively affect crop yield and the subsequent crop. Allelochemicals are known to negatively affect the growth of many plant species in e.g. the inhibition of seed germination (ADAS 2006). Unfortunately in this field, plant species used in green manuring have not been extensively studied for their allelochemical composition and effect on soils and crops being manured.

4.1 Benefits of green manure crops and green manuring

There are several benefits associated with green manure crops and green manuring which benefits maybe direct or indirect. In agriculture the overall objective of green manuring is to improve the nutrient status of the soil through decomposition and release of the nutrients locked up in the biomass for the benefit of improving agriculture crop yield. Below is a list of benefits:

When plants are grown for provision of green manures they do not only provide one product or service but are able to provide several other benefits such as food. For example, most common beans (*Phaseolus vulgaris*) when sufficiently boiled are edible as relish. Some farmers in the eastern part of Zambia process *Cajanus cajan* beans into sausages used as a snack or relish providing high proteins in diets.

Multipurpose tree species used in agroforestry for soil nutrient improvement such as *G. sepium* repel snakes, decrease soil nematode, insects and fungi populations. *Tephrosia vogelii* is used in the treatment of many diseases and control of pests (Belmain *et al.* 2012). For example, populations of the snail from the genus *Bulinus* responsible for transmitting Schistosomiasis (bilharzia) are reduced or eradicated by the use of stems and roots of *T. vogelii* (Dzenda *et al.* 2008). *Balanites aegyptiaca, Sesbania sesban,* and others also have the ability to control snails in the genus *Bullinus truncatus* and *Biomphalaria pfeifferi* (Osman *et al.* 2015).

Plants grown for biomass may also provide other products such as fuel wood, fodder, support pollination in the process play the role of gene transfer and honey provision. Generally plants act as habitat to other living organisms.

Organic matter once applied in conducive environments will stimulate soil bacteria earthworms, soil micro-flora, fungi, macro and micro-fauna which play a big role in farming, such as binding of soil aggregates together and improve soil structure (ADAS 2006). Chemical and biological properties are also improved (Rayns and Rosenfeld 2010). Organic matter enhances the formation of chelates and other soluble organic complexes helping to dissolve and mobilize some micronutrients and trace metals (the Government of Manitoba 2013) thereby improving soil growing conditions for the plant.

Soil conservation by roots breaking up compacted soils hence allowing for smooth water infiltration and reduce on water runoff is another benefit. Extensive fine roots found on plants enmesh the soil, helping to stabilise aggregates and increase pore size (PAN German 2005; ADAS 2006; Rayns and Rosenfeld 2010). Plant roots also play a role in nutrient mining by absorbing dissolved nutrients in the soil solution that is flowing towards roots as the plant takes up water. However, the amount of nutrient taken up by this process is determined by the amount of available water in the soil, the concentration of nutrients in the soil solution and the volume of water consumed by the plant.

Plants grown for provision of green manure/biomass play a role in mitigation of climate change by living plants absorbing green house gases such as carbon dioxide from the air, storing carbon in the plant mass and soil, and releasing oxygen into the atmosphere (the Forestry Commission 2005).

4.2 Disadvantages of green manure crops

Crops being grown for provision of green manures may grow vigorously hence become invasive and weed. There is also a likelihood that the green manure crop may become alternative hosts to pests and diseases for example, root knot nematodes are a host to the agroforestry multipuporse tree species *S. sesban* most promoted as a green manure crop (Desaeger and Rao 1999). Some of the agriculture crops such as tomatoes, pepper and egg plant are equally hosts to nematodes (Noling 2014). Nematode infection can lead to poor plant growth and low yields. Most agriculture crops such as beans, Brassica are vulnerable to aphids which may be hosted by green manure crops. In the aforementioned example, there is a possibility of the tree crop being an alternate host plant for aphids such that fumigation or treatment of the agriculture crop becomes difficult if grown in the neighbourhood. Another problem is that depending on the chemical content of the green manure in use, there is a possibility of altering or modifying the soil properties once applied (Bot and Benites 2005) thereby, negatively affecting the soil pH.

Some green manure material such as ground nut husks, Zea *maize* stover, wheat, *Cassia siamea* may not decompose readily due to the high C:N ratio they contain when compared with soft above ground biomass of some plant species such as *G. sepium*, *S. sesban, M. oleifera* which containing low C:N ratio. The C:N ratio is used to indicate the rate of decomposition and efficiency of nutrient release (Bot and Benites 2005). Low N and C in biomass will be depleted by micro-organisms as they need it for energy to growth during decomposition and mineralization of the biomass. Mineralization is the process of converting organic nutrients into inorganic forms by microbial activity making nutrients available to plants (Bot and Benites 2005; Government of Manitoba 2013). During mineralisation of biomass, micro-organisms require large quantities of N. On the other hand, immobilization may occur, and according to the Government of Manitoba (2013), this is when soil microorganisms feed on organic materials that contain concentrations of nutrients that are lower than their own immediate requirements. Both mineralization and immobilization are accelerated by conditions favourable for microbial growth such as moist soil, warm temperatures, good aeration, easily degradable organic substrate material, physical mixing of soil via tillage and alkaline soil pH among others (Government of Manitoba 2013).

Other disadvantages of green manuring are the need for a large amount of biomass to have the desired effects of increased crop yield. Also there is a need to invest in extra labour to establish the biomass bank, extra time to work in that field, tender, harvest and transport. However, no figures are available on the economics of establishment and maintenance of biomass banks versus other means. The question is: How profitable is the green manuring technique? Land is another resource that will be needed in-order to establish the biomass bank. Therefore, the farmer will look at opportunity costs for land, and where there is land shortage, such practices become difficult to implement.

Allelochemicals are produced from plant parts during residue decomposition, leaching, root exudation, volatilisation (Ruan *et al*. 2011; Ferguson et al. 2013), and microbial activity and these can have harmful or beneficial effects on the plants producing them or on other plants. In green manuring there is more concern with the negative effect these manures will have on the agricultural crop. Some of the negative effects of allelochemicals could be reduced seed germination and seedling growth (Ferguson *et al.* 2013). Reports indicate that allolochemicals may even lead to death of the plant being manured. For example, Pine needles are known to contain several toxins (phenolic acids) which suppress growth of plants that will come in contact with the needles. Ruan et al. (2011) described "autotoxicity as having deleterious allelopathic effect among individuals of the same species occuring in a number of coniferous species causing growth reduction under continuous monoculture practice. Examples of species with autotoxicity effects are: *Abies balsamea, Cunninghamia lanceolata, Picea abies, Picea mariana, Pinus halepensis, Pinus densiflora* and *Pinus laricio*.

Leucaena leucocephala, one of the promoted sources of green manure/biomass and also fodder for livestock, contains a toxic, non-protein amino acid (mimosine) in its leaves that inhibits the growth of other trees but not its own seedlings (Ferguson *et al.* 2013). The genera *Leucaena* and *Mimosa* contain mimosine toxic to livestock and may cause acute and chronic toxicosis (Kulp and Vulliet 1996; Meulen *et al.* 1979). Mimosine may also induce alopecia, growth retardation, cataract, decreased fertility, loss of fur and mortality in livestock due to a reduction in the activity of cellulolytic bacteria fed from forage of these plants (Meulen *et al.* 1979). The afore mentioned effects may occur if livestock is fed on the genus *Leucaena* for more than six months and in large quantities of greater than 50 times the stock feed (Meulen et al. 1979). Another example is *Tephrosia vogelii* which has growth inhibition of corn (Ferguson *et al.* 2013).

Allelochemicals can persist in soil, affecting neighbouring plants as well as those planted in succession (Ferguson *et al.* 2013). What it means here is that if green manure biomass contains allelochemicals, they may have a residual effect on the succeeding agriculture crop if it is a target. Ferguson *et al.* (2013) described "allelochemicals also having undesirable effects on non-target species, necessitating ecological studies before widespread use of green manure crops".

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Cultivation of Oyster Mushrooms (Pleurotus species)

Lorna Keumbo Maija Ester Halueendo
University of Namibia, Namibia, Faculty of Agriculture and Natural Resources, Ogongo Campus

1. Introduction

Poverty alleviation, especially among rural communities, is a priority of most governments in the world. In most rural areas, natural resources are the main drivers of economic growth and development when their full potential is unlocked. It is thus imperative that governments look at ways of educating communities on how to sustainably utilize natural resources to improve their livelihoods (Republic of Namibia 2009). Such resources include wild mushrooms and the materials used to cultivate mushrooms.

2. Mushrooms and their importance

Mushrooms belong to the kingdom Fungi. All fungi have a distinct cellular structure but they lack chlorophyll and are thus unable to produce their own food. They depend on other organisms for food. With the exception of yeast, all fungi grow by forming hyphae, tiny threads originating from the spores. The hyphae branch out to form the mycelia. After fertilization, they enter a sexual phase and produce spores, of which the large spore-producing structures (larger than 1mm) are called mushrooms (Oei 2003).

Mushrooms have been consumed/used around the word for their nutritional and medicinal (or tonic to enhance health) properties. They contain high amounts of proteins, vitamins (B1, B2, and C) and minerals as well as being very low in cholesterol (Oei 2003). Currently, the medicinal effects of mushrooms are mostly restricted to the prevention or outgrowth of diseases and less of a healing effect. It has been reported that there are more than 700 commercial medicinal products in China with mushrooms a main ingredient that prevent heart and coronary diseases, cancer, diabetes, and prevent against free radicals and infections. In addition to nutritional and medicinal value, mushrooms also serve as a source of income generation due to their comparatively high prices, their use as a natural dye for fabrics, and also to bioremediate polluted soil or neutralize acidic runoff (Oei 2003).

People have harvested wild edible mushrooms since time immemorial. They have been eaten fresh or dried for later use. In some cultures, mushrooms were only eaten by elders, kings or emperors, and some only ate mushrooms on special occasions. Currently, the migration of many people with varying food habits across the globe has and is still spreading the popularity of mushrooms (Oei 2003). In Africa, mushrooms are conceived by local people as their unique treasures for use as food and medicine (Mshigeni 2012).

Although mushroom cultivation industries have existed for a long time, some edible mushrooms are still gathered for consumption in many communities, as their cultivation parameters are still not known. This is especially so with the species that live in association with other organisms, such as the Termitomyces that grows on ant hills. Despite the collection of wild mushrooms, people are also sometimes met with the fear that poisonous mushrooms exist.

3. Mushroom cultivation

The benefits and seasonal availability (during the rainy season) of mushrooms have increased the popularity of mushroom cultivation throughout the years all over the word. However, although cultivation started as early as 1313 in China, its success was long awaited because the biology of fungi was not well understood. Currently there are a number of commonly edible and medicinal cultivated mushrooms such as: Agaricus bisporus (white button mushrooms), Pleurotus species (oyster mushrooms) (Figure 1), Flammulina velutipes, Lentinula species (shiitake) and Ganoderma species (Kadhila-Muandingi and Mubiana 2004). For this article, the focus will be on oyster mushrooms (Pleurotus ostreatus and soja-caju).

Figure 1. Oyster Mushrooms (Pleurotus ostreatus). Photo by K. E. Mshigeni.

The utilization of local raw materials as substrates (materials where the mycelia grow) for mushroom cultivation is not only crucial in producing a good crop, but also in sustaining livelihoods. This is especially significant in the approach of integrated agricultural production, where waste from one agricultural entity serves as raw material in another entity. This approach is also very important in stepping towards the concept of zero emissions, thus protecting the environment and minimizing the effects of global warming.

There are several major practical phases in mushroom cultivation such as medium and culture preparation, spawn development, substrate preparation, management of the fruiting phase, and pests and diseases management.

3.1 Mushroom culture

Different artificial media such as Potato Dextrose Agar (PDA) or Malt Extract Agar (MEA) are essential in culture development and are prepared according to recommended instructions (Biolab, Johannesburg, South Africa) and poured in petri dishes. The culture is prepared by plating pieces of healthy, young and clean mushrooms after which the petri dishes are labeled with the date and mushroom strain and incubated at 25°C until the mycelia is fully grown (Figure 2). A fresh mushroom culture from a reliable source can also be used for culture development. It is very crucial that the procedures are conducted under aseptic conditions in a laminar flow or in a clean/disinfected surface to avoid/minimize contamination (Kadhila-Muandingi & Mubiana 2004).

Figure 2. Fully grown mushroom culture. Photo by Lorna Halueendo.

3.2 Mushroom spawn (mushroom seeds)

The key component in the mushroom growing/cultivating process is the development of spawns (mushroom seed) (Wach 2012). Spawns grow on a variety of materials such as sorghum, millet or wheat grains, saw dust or cotton seed shell. Every mushroom growing cycle should start with a fresh spawn to avoid contamination and degeneration when the mycelia becomes old. This is essential in producing a good crop. It is therefore recommended that the saw dust, cotton seed shells and other materials used for spawn development must be very clean, have few broken kernels and be free from pathogens or insect infestation. This phase requires a clean laboratory or clean room. Equipment such as an autoclave to sterilize the grains at 121°C or a pressure cooker is essential for contaminant elimination. Since mycelia growth requires certain moisture content, seeds or other materials are soaked and dried to 40-60% before they are transferred to heat resistant bottles and autoclaved/sterilized for 20 minutes. The grains can alternatively be cooked in the drum on open fire for 1 to 5 hours (Kadhila-Muandingi and Mubiana 2004). When the grains have cooled down, pieces of pure culture are transferred to the grains, by using clean, disinfected blades and scalpels (Figure 3). The utensils should always be disinfected by dipping in 70% ethanol or spirit and flaming them before use. This ensures the removal of contaminants. This procedure is carried out in the laminar flow or disinfected surfaces. The bottles are incubated at 25°C for 2-3 weeks or until the grains are fully invaded by the mycelia (figure 4) and ready for substrate cultivation.

Figure 3. Spawn development in the laminar flow. Photo in courtesy of Nailoke Kadhila-Muandingi.

Figure 4. Ready spawn (mushroom seeds) Photo by Lorna Halueendo.

3.3 Mushroom substrate

Mushroom substrate is a lignocelluloses material that supports the growth, development and fruiting of mushroom mycelia. Substrate properties determine the type of fungi that can grow on it. Other environmental factors that contribute to mycelia growth on the substrate are: air humidity, ventilation, shade or sun and temperature. There is a wide range of materials that can be used as substrate depending on the availability. Raw materials such as field grass, maize, sorghum, millet or rice straw, millet chaff, saw dust and compost can be used, depending on the mushroom strain. However, for materials like saw dust care must be taken not to use the chemically treated one because it kills the fungus (Kadhila-Muandingi and Mubiana 2004). For oyster mushrooms, the commonly used substrates are wheat, sorghum, millet, rice, barley and cotton straws, field grass, wood logs, sawdust, corn cobs, cotton waste, water hyacinth etc. (Oei 2003).

The selected substrate should be cut into pieces of 1-5cm and soaked for about 5-8 hours to allow for mycelia growth. Excess water should however be removed to the moisture content of 50-60% to avoid decay. It is recommended that the substrate be thoroughly mixed with 1-1.5% lime (% of the dry weight of the substrate) (Figure 5).

Figure 5. Substrate preparation. Photo by Lorna Halueendo.

This is essential in maintaining a neutral pH, which is ideal for oyster mushrooms' growth. In order to remove the contaminants, the substrate is bagged in heat resistant clear plastic bags, after which the bags are placed in drums or pasteurization chambers for 4-5 hours which can either be electrified or open fire based (Figure 6). The steam produced by boiling water will remove the contaminants that would have otherwise competed with the mushrooms (Oei 2003; Kadhila-Muandingi and Mubiana 2004). After the substrate has cooled down, clean spawn is used to inoculate (cultivate the substrate).

Figure 6. Substrate pasteurization using local materials in Namibia. Photo by Lorna Halueendo.

3.4 Mushroom vegetative and fruiting phase

After inoculation, the bags are incubated in a room with weak light or near darkness at temperatures of 20-25°C and humidity of not more than 60%, to avoid contamination. The room should be ventilated at least once a day for 30 -40 minutes at a time for 10 days. Once the substrate is almost fully invaded by mycelia (Figure 7), the bags should be transferred to the fruiting house (mushroom growing house). In this house, slits are made on the sides of the bags, making sure that the blade is disinfected to avoid contamination. Temperatures of 15-25°C, humidity of 75 – 90% and good ventilation should be maintained. The first flashes of mushrooms are normally visible in 7 days after opening the bags and 2-3 days later to become full grown mushrooms (Oei 2003; Kadhila-Muandingi and Mubiana 2004).

Figure 7. Substrate fully invaded by mycelia

3.5 Harvesting and packaging

Mushrooms are very delicate; thus harvesting should be done gently and proper materials such as ventilated baskets, paper bags and cartoons are highly recommended to prolong the shelf life of the crop (Oei 2003; Kadhila-Muandingi and Mubiana 2003)

3.6 Mushroom houses

A variety of materials (Figure 8a-d) can be used to construct a mushroom house, depending on their availability. However, measures to maintain the optimum or ideal conditions inside the house should be taken into consideration. That is, the material should be able to maintain the temperature and humidity.

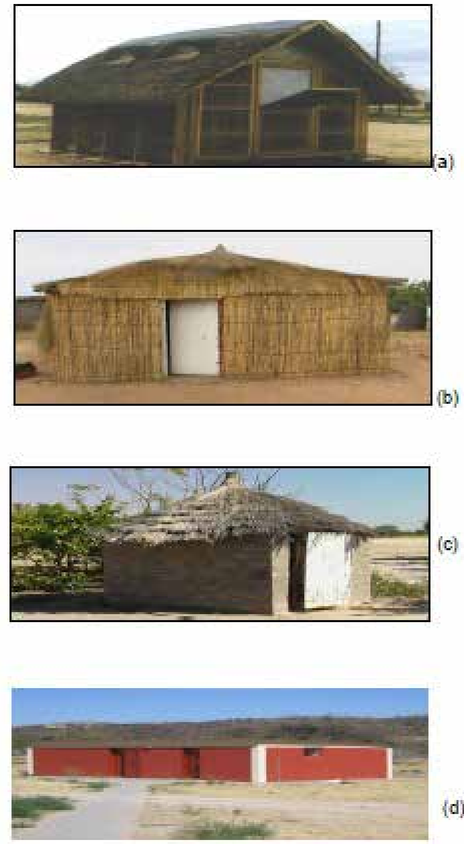

Figure 8. Variety of materials (a-d) that may be used to construct a mushroom house

3.7 Pests and diseases

Pests and disease incidences are responsible for serious management and economic problems to mushroom growers (Deakin et al. 2012). These are mostly caused by fungi, bacteria, viruses. It is therefore important that the crop should be managed in ways that yield a good crop in terms of both quality and quantity. Although the use of chemicals in crop production is inevitable, health implications emanating from this are also becoming the most important aspects of our daily lives. It is therefore very crucial that chemicals' use in production is minimized to ensure human health and maintain environmental integrity. In mushroom production, it is recommended that general hygiene should always be the key factor in preventing pest and diseases outbreak. Mushroom growers and their workers should be trained and maintain their general cleanness and that of the surrounding environment. Alternatively, approaches such as the use of misting devices (to create unconducive environments for pests and diseases), UV-C Light, hot water (steam cleaners) and others should be used depending on the practical applicability of the approach (den Ouden 2012).

4. Conclusion

The utilization of natural resources is very crucial to the livelihoods of communities. This should however be accompanied with education and training on sustainability, so that resources are also maintained for future generations. Mushrooms cultivation is one entity that can be embarked on at the community level because of the nutritional, medicinal and economic value. If approached strategically, it will contribute massively to poverty alleviation, especially among the rural communities.

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Chapter 2. Sustainable Agriculture and Livelihood

Sustainable Agricultural Systems in Zambia: a Case of Conservation Agriculture with Trees

Donald Zulu, Darius Phiri and Exilda Chisha–Kasumu
Copperbelt University, Zambia, School of Natural Resources,
Department of Plant and Environmental Sciences

1. Introduction

Agriculture is an indispensable sector in Zambia and generates between 18 - 20% of the Gross Domestic Product (GDP) and its contribution to the total foreign exchange earnings is estimated between 3 - 5%. It provides livelihood to more than 70 percent of the population. The sector absorbs about 67 % of the labour force and remains the main source of income and employment for both rural women and men, whose population is 4,012,580 and 3,906,636, respectively. (CSO, 2010; NAP 2004). This important sector is however faced with numerous challenges.

Low soil fertility associated with unsustainable farming methods and extreme weather events attributed to climate change are increasingly recognised as fundamental challenges to increasing and sustaining agricultural productivity in the country (Sanchez, 2002; Gregory, et al 2005). Some of the factors contributing to low soil fertility involve the breakdown of the traditional fallow system due to population increase which forces farmers to crop continuously on the same piece of land (Kwesiga et al 1999); maize mono-cropping; continuous deep ploughing (CFU, 2008); low adoption of sustainable soil fertility management options; injudicious use and sub optimal use of mineral fertilizers by majority of smallholder farmers because of high cost and constraint to access them (Ajayi et al 2011; Howard and Mungoma, 1996). According to the Millennium Ecosystem Assessment (MEA, 2005), the World Development Report 2008 (WDR,

2008) and the IAASTD reports (McIntyre et al., 2008), unsustainable agricultural systems are still being promoted with unacceptably high environmental, economic and social costs, albeit with the promise of gains in output (Kassam et al 2009). Climate change on the other hand is envisaged to continue bringing severe weather extremes especially in the form of droughts, frequent and prolonged dry spells, fluctuations in annual rainfall and extreme temperatures. These impacts have often resulted in widespread unstable food production especially among resource constrained smallholder farmers (Gregory, et al 2005). The two challenges of low soil fertility and extreme weather events negatively affect smallholder farmers, hence having grave consequences on poverty, food and income security.

The development community including governments, funding agencies, academics, scientists and extension workers have been highlighting the need for the development of sustainable agricultural systems that could respond to these challenges (Kassam et al 2009). Sustainable agricultural systems could balance seemingly conflicting goals of agricultural production with environmental stewardship (Ajayi et al 2007).

1.1 What is Sustainable Agriculture?

The word "sustain," from the Latin word sustinere (sus-, from below and tenere, to hold), means to keep in existence or maintain and has implication of long-term support or permanence. The word sustainability is best defined with a quote from Paul Hawken:

"Leave the world better than you found it, take no more than you need, try not to harm life or the environment, make amends if you do."

Sustainable agriculture therefore is a farming system that is "capable of maintaining its productivity and usefulness to society indefinitely. Agriculture to be sustainable, it should be resource-conserving, socially supportive, commercially competitive, and environmentally sound." (Duesterhaus, 1990). Furthermore, Crosson (1992) defines a sustainable agricultural system as one that can meet demands for food and fiber indefinitely at socially acceptable economic and environmental costs. The main aim of sustainable agriculture is to provide long-term sustained yields through the use of ecologically sound management techniques.

2. Sustainable agricultural systems in Zambia

Globally there are several different sustainable agricultural systems developed and promoted for specific agroecological region. Some of the systems include agroecology, ecological agriculture, biological agriculture, regenerative agriculture, permaculture, biodynamic agriculture, low external input agriculture, agroforestry, organic agriculture and conservation agriculture (Pretty and Hine, 2001). Each of these systems have their own unique background, genesis, emphasis, advantages and limitations although environmental management is central to all. Sustainable agricultural systems developed, adapted and or promoted in Zambia by various governmental and non-governmental organizations include conservation agriculture, organic agriculture and agroforestry. In this chapter we will focus on conservation agriculture and agroforestry. Organic agriculture is discussed in the next chapter.

3. Conservation agriculture

3.1. What is conservation agriculture and what are its benefits?

Conservation agriculture was born out of the 1930s dustbowl were farmers in the American Midwest were forced to abandon 40 million hectares of land. The dustbowl was created by a combination of drought, loss of natural vegetation, and deep ploughing of vast semi-arid prairie lands (FAO, 2001). Conservation agriculture was developed to address the challenges of soil degradation resulting from unsustainable agricultural practices that often deplete organic matter and nutrient content of the soil. The system further addresses the problem of intensive labour requirement. It increases rainwater use efficiency and labour productivity resulting in higher and stable yields while reducing production costs. Conservation agriculture can therefore be defined as a resource efficient agricultural crop production system based on an integrated management of soil, water and biological resources combined with external inputs (FAO 2008). Conservation agriculture is based on three reinforcing principles involving (1) minimum or no mechanical soil disturbance; (2) permanent organic soil cover consisting of a growing crop or dead mulch of crop residues and (3) diversified crop rotation (Hobbs, 2008). It represents a fundamental change to agriculture production system. Conservation agriculture functions best when all the three key principles are simultaneously combined together in the field.

Principle 1: Minimum or no mechanical soil disturbance

Instead of ploughing or turning the soil and harrowing, the soil could be sub-soiled using a sub-soiler or a ripper to make furrows for seed placement. For hoe farmers, a special hoe known as a *chaka* hoe could be used to make precise planting basins for seed placement (CFU, 2008).

Benefits of **minimum soil disturbance** include:

Minimum soil disturbance prevents further destruction of the valuable soils from agents of erosion. It also increases water and nutrient use efficiency and labour productivity.

Principle 2: Crop rotation

The second principle involves crop rotation, a practice of growing two (or more) dissimilar types of crops in the same space in sequence. Cereal crops like maize could be rotated with legumes, deep-rooted crops and crops that produce high quantities of residues.

Some of the benefits of crop rotation include:

- Improves soil structure as some crops have strong deep roots which can penetrate deep into the soil breaking hard pans, and can tap moisture and nutrients from deep in the soil and recycle them. Others have shallow roots and tap nutrients near the soil surface.
- When leguminous crops are part of the rotation, they fix nitrogen into the soil and their biomass adds nitrogen through decomposition.
- Crop rotation helps in controlling some weeds, pests and diseases. Planting of the same crop season after season may encourage certain weeds, insects and diseases to thrive. Planting different crops season after season breaks their life cycle and prevents them from multiplying.

- Growing a mix of grain, beans, vegetables and fodder means a more varied diet and more types of produce to sell.
- Rotating crops stimulates a diversity of soil organisms.
- It leads to balanced nutrient usage.
- Reduces erosion.
- Increases yields, hence profits (Mutua *et al* 2014).

Principle 3: Maximum soil cover

Maximum soil cover is the defining aspect of conservation agriculture. The aim is to have a protective layer above the soil surface. This is done by inclusion of live cover crops such as Dolichos lablab, Mucuna bean, Crotalaria species and cow peas or spreading of dead vegetative material, mainly from crop residue. Agroforestry tree species can also be used to provide aerial soil cover (Mutua et al 2014; Hobbs, 2008).

The **benefits of soil cover** include:

- Soil cover protects the soil from erosion and at least 30% soil cover is required to control 30% of erosion.
- Soil cover helps in suppressing weeds by smothering their growth and reducing the number of weed seeds hence reducing labour requirements for weeding.
- When leguminous cover crops are used, they increase the soil fertility and organic matter content of the soil. An increase in organic matter further increase soil moisture retention.
- Soil organisms, earthworms and microorganisms can prosper under the soil cover as well as in the soil (Mutua *et al* 2014)

3.2. Challenges of Conservation Agriculture

Even with its huge promise, conservation agriculture has its own limitations and some of them include:

- The uptake of conservation agriculture by farmers, especially smallholders, has not been as anticipated. This is attributed to the fixed mind set of the farmers in their cultivation culture, coupled with other constraints associated with the technology such as availability and cost of inputs, competing use of crop residues, weeds and initial labour requirement (Mutua *et al* 2014; Giller *et al* 2009).
- Limited availability of crop residues is an important constraint to adoption of conservation agriculture. Mulching with crop residues often competes with other use such as fodder and fuel material. For example crop residues such as cereal stover provide highly valued fodder for livestock in smallholder farming systems and livestock feeding mostly takes precedence given the economic importance of livestock as an investment and insurance against risk, for traction, manure, milk and meat.
- In the early years of adopting conservation agriculture, minimum tillage normally results in increased weed pressure. This could increase the amount of labour required to weed in the absence of herbicides.
- Farmers tend to grow legumes on smaller proportion of land in relation to cereal crops making it difficult to implement a good crop rotation program. Some of the reasons for this include lack of market for legumes especially green manure crops and hence insufficient incentive for growing them to fertilize the fields.
- Many synergistic interactions between components of conservation agriculture practices are not yet fully understood. Generally, scientific research on conservation agriculture system lags behind what farmers are discovering and adapting on their own initiative.

4. Agroforestry

4.1. The genesis and definition of agroforestry

The genesis of agroforestry can be traced back to the 1970s global challenges of deforestation, environmental degradation, energy and food crisis. The defining moment however came when Bene et al (1977) published a comprehensive report supported by the International Development Research Centre (IDRC) of Canada. Bene *et al* (1977) recommended for research in agroforestry and further proposed how agroforestry research and development should be undertaken. Their recommendation is summarized in this extract: *"A new front can and should be opened in the war against hunger, inadequate shelter, and environmental degradation. This war can be fought with weapons that have been in the arsenal of rural people since time immemorial, and no radical change in their life style is required. This can best be accomplished by the creation of an internationally financed council for research in agroforestry, to administer a comprehensive program leading to better land-use in the tropics (Bene et al., 1977)".* This led to the establishment of the International Council for Research in Agroforestry (ICRAF) which was later renamed as the International Centre for Research in Agroforestry (ICRAF) upon joining CGIAR and it is now known as the World Agroforestry Centre.

Agroforestry is defined as a set of land use practices that involve deliberate combination of trees/shrubs with agricultural crops and or animals on the same land management unit (Sinclair, 1999). For over 20 years, farmers and researchers have been adapting and developing agroforestry technologies and options suitable for addressing challenges facing smallholder agricultural production and the environment in Zambia and the sub region. The main types of agroforestry technologies developed for Zambia and the sub region include fertilizer tree systems for replenishing soil fertility, rotational woodlots for solving fuelwood problems, fodder banks to supplement feed for livestock, and indigenous fruit trees for improving nutrition during the seasonal hunger periods (Ajayi et al 2008).

4.2. Fertilizer tree systems

Fertilizer tree systems is the pioneer agroforestry technologies in Southern African. Its development began in Zambia and it includes improved tree fallows common in eastern Zambia and mixed intercropping technologies popular in Malawi. Mechanisms for managing soil fertility with fertilizer trees are based on biological nitrogen fixation by leguminous trees and shrubs, biomass production and nutrient recycling (Ajayi *et al* 2008). The main practices under fertilizer tree systems include scattered leguminous trees on farm land often with *Faidherbia albida*; improved fallows with *Cajanus cajan*, *Teprosia vogelii*, *Tephrosia candida*, *Gliricidia sepium*, and *Sesbania sesban*; tree – crop intercropping and biomass transfer with *Gliricidia sepium* – *Zea mays* (Mafongoya *et al.*, 2006; Sileshi *et al.*, 2008).

4.3. Rotational woodlots

Rotational woodlots were developed primarily to provide high-quality wood biomass. Some of the woodlot species also help to fertilize the soil and are therefore grown in rotation with food crops (Kwesiga et al., 2003). The main woodlot species in Zambia include Senna siamea, Leucaena leucocephala, Acacia crassicarpa, and Acacia auriculiformis (Ajayi et al 2008).

4.4. Fodder banks

This agroforestry technology is designed to reduce the cost of formulated animal concentrate feeds for smallholder farmers and was developed in Zimbabwe. This involves the growing, harvesting, and preservation of browse of nutritious protein-rich leguminous tree leaves during the wet season and using them as protein supplement for ruminant animals during the long dry season. The main fodder species common in Zambia include *Leucaena leucocephala, Gliricidia sepium, Morus species* and *Moringa oleifera* (Ajayi *et al* 2008).

4.5. Fruit trees

The indigenous fruit tree domestication program is aimed at building on the desire of rural communities to cultivate indigenous fruits and nuts to meet their livelihood needs, such as food and nutritional security, increase household income and diversify farming systems. Developing indigenous fruit trees into tree crop systems continue to be an important agroforestry strategy in Zambia and the region (Akinnifesi et al., 2006). The four priority indigenous fruit tree species that that have been the focus of research in Southern Africa are *Uapaca kirkiana, Strychnos cocculoides, Parinari curatellifolia,* and *Sclerocarya birrea* (Ajayi et al 2008). Exotic fruit trees have been deliberately included in the fruit tree research and development agenda.

4.6. Benefits of agroforestry

Agroforestry technologies offer multiple benefits and some of the benefits include:

- The most pronounced benefits of agroforestry technologies are on improved soil fertility. Improved soil fertility has a positive effect on food and income security. Fertilizer trees for example could increase maize yield by 2 - 3 times compared with the conventional practice of continuous maize without nutrient inputs (Kwesiga et al., 2003; Akinnifesi et al., 2006). Furthermore, agroforestry technologies have been found to be profitable relative to conventional production practices where trees are not grown (Ajayi et al., 2006).
- Agroforestry technologies also lead to improved soil physical properties through higher soil aggregation hence improving water infiltration and water-holding capacity (Phiri et al., 2003). Improvement in soil aggregation and water-holding capacity could help in minimizing the risk of low productivity in of drought.
- The trees have overall net positive impact on the soil invertebrates and these perform important ecosystem functions, e.g., soil processes (Sileshi and Mafongoya, 2006).
- Fertilizer trees reduce the incidence of noxious weeds such as *Striga hermonthica*, which thrives well in poor soils (Kwesiga et al., 1999). This aspect of fertilizer trees provides a big incentive for women who are often responsible for weeding the family's fields.
- Agroforestry technologies normally lead to increased firewood supply mainly from woodlots and rotational improved fallows. These technologies can supply up to 10 tons of wood biomass/ha (Kwesiga and Coe, 1994) and this can contribute to the reduction of the deforestation of the miombo woodland. Furthermore it can greatly reduce the burden on women who often carry firewood over long distances.
- Agroforestry technologies have been found to significantly sequester carbon and the carbon stored in agroforestry fields could vary between 2.5 and 3.6 tons/ha/year (Ajayi et al 2008).

4.7. Challenges

This tree and shrub based farming system equally has its own challenges and some of them include:

- Generally uptake of agroforestry technologies is more complicated than of annual crops (Scherr and Müller, 1991; Mercer, 2004) due to its multiple components. A global review on the adoption of agroforestry shows that diffusion of agroforestry technologies has lagged behind scientific and technological advances (Mercer, 2004). In Zambia, some of the factors limiting agroforestry adoption include local customary practices involving incidence of bush fires and uncontrolled browsing by livestock during the dry season and absence of perennial private right over. Indiscriminate bush fires often destroy established trees on farmlands in the absence of effective fire breaks. Animals also destroy the established trees by browsing them. These bottlenecks can be resolved by engaging traditional rulers and government (Ajayi and Kwesiga, 2003).
- Limited agroforestry knowledge is also a huge challenge. This could be due to the nature of the system which is generally knowledge intensive and is relatively a new field. Capacity building at different levels is therefore needed.
- One of the greatest challenges of some agroforestry technologies is the lack of access to quality seeds. Agroforestry tree and shrub seeds lack a formal seed systems of multiplication and distribution.
- Lastly, farmers are normally discouraged to venture into agroforestry due to the long period (time) required to accrue benefits from them.

5. Conclusion

The two sustainable agricultural systems involving conservation agriculture and agroforestry evolved independently. They have been introduced, refined and adapted in the country by farmers and scientists from national and international research and development. Each of the above systems of sustainable agriculture has its own unique strengths and weaknesses. Conservation agriculture often reduces the labour requirements, costs of land preparation, encourages timely planting of crops, controls erosion and helps improve soil fertility which subsequently leads to improved crop yields. However, in the absence of herbicides or cover crops, labour requirements for weeding may significantly increase especially in the initial years of uptake. The other challenge is the competition for crop residues between using them as mulch or livestock feed and this needs a sustainable solution. Agroforestry also increases soil fertility and enables farmers to double or triple maize yields. Fertilizer trees also help in suppressing weeds hence reducing the labour of hand weeding. However, additional labour is often required to establish and maintain agroforestry technologies. Thus agroforestry technologies are generally more labour-intensive than conventional cropping system especially in the initial first or second years of uptake. Each of these sustainable agricultural systems appears to work best in specific agro-ecological zones under specific biophysical and economic conditions. The challenge is to identify which system works best in each locality. Probably by applying the best of each of these systems could lead to new options for better management of the land and to increase smallholder food production.

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Sustainable Agricultural Systems in Zambia: a Case of Organic Agriculture

Donald Zulu, Darius Phiri and Exilda Chisha–Kasumu
Copperbelt University, Zambia, School of Natural Resources,
Department of Plant and Environmental Sciences

1. Introduction

Declining soil fertility and climate change are some of the major challenges impeding agricultural productivity in Zambia (Sanchez, 2002; Gregory, et al 2005). The decline in soil fertility in Zambia is often attributed to unsustainable agricultural practices (Kwesiga et al 1999; CFU, 2008). Climate change will continue to bring severe weather extremes especially in the form of droughts, frequent and prolonged dry spells, fluctuations in annual rainfall and extreme temperatures. These impacts have often resulted in widespread unstable food production especially among resource constrained smallholder farmers (Gregory, et al 2005). Sustainable agricultural systems could simultaneously respond to these challenges and balance seemingly conflicting goals of agricultural production with environmental stewardship. (Ajayi et al 2007). In this chapter we focus on organic agriculture, a sustainable agricultural system gaining momentum in Zambia.

2. What is organic agriculture?

The growth in interest in organic agriculture is often attributed to the challenges of declining soil fertility; pollution of soil, water and food with pesticides and nitrates hence having an effect on the health of farmers, farm workers, farm families and rural communities; resistance of pests to pesticides; and dependence on off-farm agricultural inputs which can increase poor farmers' dependence on credit facilities (to purchase synthetic fertilizers, pesticides and seed), which may result in decreased local food security, sovereignty and self-reliance (FAO, 1999). Organic agriculture focuses on maintaining and improving the overall health of the individual farm's soil-plant-animal system as a holistic approach which affects present and future yields. The IFOAM (2008) defines Organic Agriculture as a *"production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved"*. The FAO/WHO (1999) in the Codex Alimentarius defines Organic agriculture as *"a holistic production management system which promotes and enhances agroecosystem health, including biodiversity, biological cycles, and soil biological activity"*. Organic agriculture could be best described as a system of agriculture which prohibits use of synthetic fertilizers and pesticides and relies on biological processes.

This system of farming is based on four principles which are considered the bedrock upon which it should grow and develop. These principles express the contribution that organic agriculture can make to agriculture in a global context and these include:

1. The principle of health: Organic agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.

2. The principle of ecology: Organic agriculture should be based on living ecological systems and cycles.

3. The principle of fairness: Organic agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.

4. The principle of care: Organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment (IFOAM, 2008).

3. Organic fertilization

The key to success in organic agriculture is the recognition of the importance of long term soil fertility management. Soil fertility in organic agriculture is managed through use of organic fertilizers such as compost, animal manure, fertilizer trees and herbaceous legumes which have long been known to manage soil fertility sustainably. Organic fertilization is the most important requirement for achieving production goals (Mafongoya et al 2006) in organic agriculture. Even pest and disease management hinges on this requirement. Fig 1: shows the commonly used organic fertilizers in Zambia.

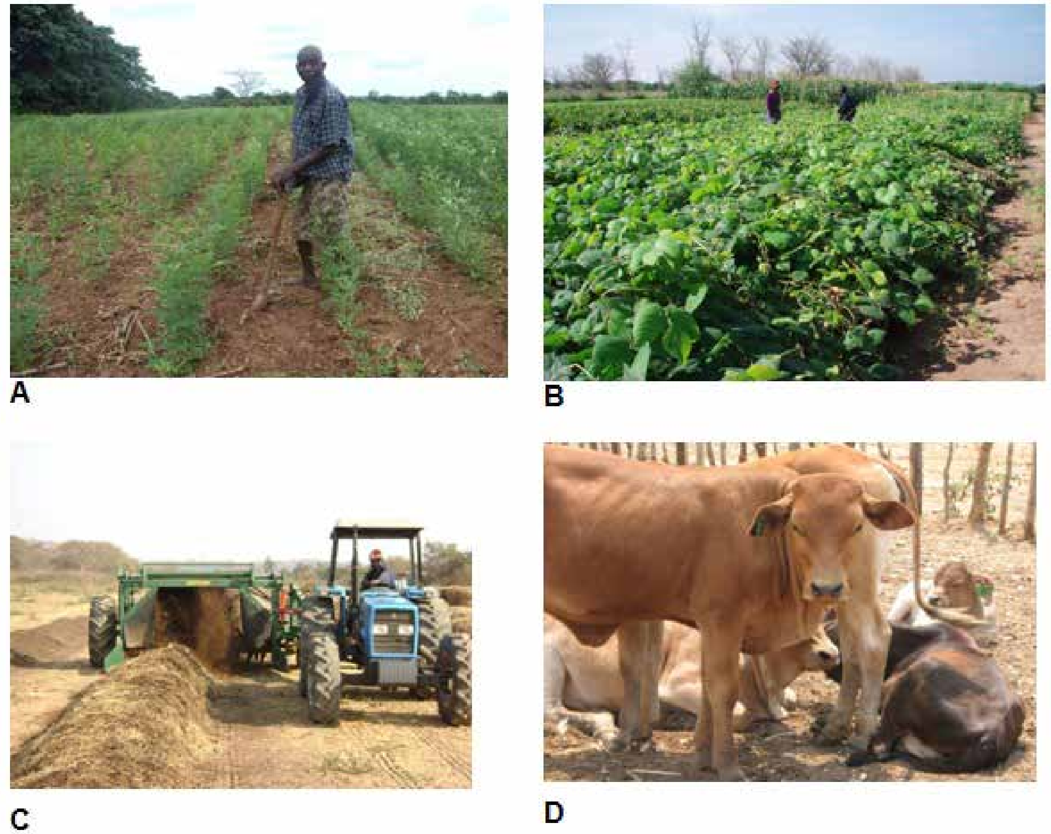

Figure 1. Organic fertilizers, A: Fertilizer tree field with Cajanus cajan; B: Herbaceous legume Mucuna pruriens; C: large scale compost making; D: Cattle crucial for providing animal manure.

4. Organic pest management

Pest management in organic agriculture comprises of preventive and curative strategies. Preventive strategies involve designing the crop fields that will sustainably manage pests through the push and pull mechanism. The push component includes the use of crop repellents such as marigold onion, lemon grass, rosemary, chilli and mint while the pull crops. Curative strategies involves use of botanical pesticides which are rudimentary prepared from plant parts such as neem leaves, chilli pods and marigold leaves.

Below are some of the benefits of adopting organic agriculture:

» Organic agriculture is based on organic matter technologies such as animal, compost, green manures and fertilizer trees to fertilize crops. These technologies have long been known to improve soil fertility. Organic agriculture therefore leads to improved soil health and greater productivity.

» With significant amount of organic matter addition, soils under organic agriculture capture and store more water than soils under conventional cultivation (Niggli et al. 2008). Organic agricultural systems are therefore less prone to extreme weather conditions, especially drought (IPCC 2007).

» Soil carbon sequestration is high in organic agricultural systems through agricultural management practices such as organic manures which promote greater soil organic matter (and thus soil organic carbon) content (Niggli et al. 2008).

» Organic agriculture comprises highly diverse plants and animal types hence having a positive effect on biodiversity. Furthermore, organic agriculture increases the diversity of income sources. Crops and crop varieties used in organic agriculture are usually well adapted to the local environment.

» It is widely known that a large number of people in agricultural production are affected by use of agrochemicals. Therefore, one of the most direct health benefit of organic agriculture is the omission of pesticides which offers safer working conditions for farmers and farm workers. Furthermore, there is reduced risk of contamination of food and water under organic agricultural systems.

Challenges of organic agriculture

» Farmers normally experience yield losses when converting to organic production systems because of a period of time between the discarding of synthetic inputs and the restoration of sufficient biological processes needed to control pests and improve the soil health. The degree of yield loss varies depending on factors such as the inherent biological attributes of the farm, farmer expertise and the extent to which synthetic inputs were used under the previous management system. Where soil fertility is low and biological processes have been seriously degraded, it may take years to restore the ecosystem to the point where organic production is possible. In such cases other logical and sustainable approaches, which allow judicious use of synthetic chemicals (and slowly reduce quantities used until all chemicals are completely eliminated), may be more suitable start-up solutions. Another strategy to survive the difficult transition period would involve converting the farm to organic production in partial instalments so that the entire operation is not at risk. This should be emphasized when promoting organic agriculture among resource constrained smallholder farmers who solely depend on farming for food and income.

» Organic agriculture generally requires significantly greater labour input than conventional farms. This is one of the greatest impediment to adoption of organic agriculture by resource constrained smallholder farmers. For example, it is difficult for most small-scale farmers to produce and transport about 10 – 20 tonnes per ha of organic manure necessary to fertilize maize crops (Mafongoya et al 2006).

» Organic agricultural promotional efforts in Zambia is happening in a policy vacuum. Government support in the form of programs is nonexistent. Policy development would be the first progressive step in supporting organic agriculture.

» Organic agriculture has received very limited research attention in the country hence negatively affecting the promotional efforts which are happening in the absence of localized agronomic recommendations (FAO 1999).

5. Conclusion

Organic agriculture is a sustainable agricultural system that is based on biological processes to fertilize crops and manage pests and diseases. Organic agriculture improves soil fertility leading to higher yield and improves the overall agroecosystem health and stability. It also offers health benefits to farmers and consumers through non-use of agricultural chemicals. The main challenge with organic agriculture in Zambia and the region is limited research. Research is needed to devise ways of addressing the challenges of increased labour demands, dealing with huge quantities of organic fertilizers, sustainably managing pests and diseases and how to convert to organic agriculture without suffering huge yield losses especially under smallholder farmers.

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Wastewater Production, Treatment and Use in Zambia

Paul Simfukwe
Mulungushi University, Zambia, School of Agriculture and Natural Resources

1. Introduction

What is wastewater?

Wastewater (Waste + water) is water considered as waste after use in a particular process. The urban wastewater comprises one or more of the following: 1. Domestic effluent consisting of black water generated from excreta, urine and associated sludge and greywater from kitchen and bathroom use; 2. Effluent from commercial establishments and institutions, including hospitals and 3. Storm water and other urban run-off. This article highlights the types of wastewater and their use in agriculture in Zambia. It also highlights the production and challenges faced in the treatment of wastewater and finally the safe use of wastewater in agriculture.

2. Wastewater use in agriculture

According to the 2006 WHO report, about 10 % of the world population consumes foods produced by irrigation with wastewater with the larger percentage in low income countries with arid and semi-arid climates. The use of wastewater has occurred traditionally for centuries in many countries and is quite a widespread practice in urban and peri-urban agriculture in less industrialised countries. In Zambia, wastewater is used in urban and peri-urban areas by smallholder farmers for agriculture to secure their livelihoods and opportunities and adds importantly to their food security.

Wastewater used for agricultural irrigation is of varying quality, ranging from raw to treated wastewater. Treated wastewater is one which has been processed through a treatment plant. The treatment consists of one or more physical, chemical, and biological processes to reduce its pollution and health hazard. Reclaimed or treated wastewater can officially be used under controlled conditions for beneficial purposes, e.g. irrigation. Greywater generated from households not connected to sewerage system can be treated and used for irrigation of home gardens and trees as an important component of water conservation and offers a great potential as an economic and resource conservation component of the integrated water resources management in dry areas. Untreated wastewater from the sewage outlets has also been used directly or indirectly (abstracting water from rivers contaminated with untreated wastewater) for agricultural cultivation. Wastewater use can be a planed activity where there is a conscious and controlled use of wastewater either raw or diluted. In most developing countries including Zambia, there is no separation of domestic effluent into black and grey water and usually the use wastewater is not planned. Characteristic in these countries is also the lack of a comprehensive sewage collection network and drainage systems therefore, collected wastewater is discharged into rivers before treatment.

3. Why use wastewater in agriculture

The principle forces that drive the use of wastewater are: Population growth and rapid urbanization are intensifying pressure on fresh water resources; The lack of quality water and high level of local water demand are leading to increasing water scarcity and stress forcing people to resort to non conventional waters and; the recognition of the value of wastewater for agricultural purposes. In urban and peri-urban areas wastewater can serve as a source of water and fertilizer, if it is well managed to minimize environmental and health risk.

4. Production and treatment of wastewater

In Zambia wastewater is produced from: Domestic effluent consisting of blackwater and greywater; commercial establishments and industrial effluent and; storm water. The Municipal domestic wastewater is treated using the centralised systems by using stabilisation ponds consisting of the anaerobic stage where there is a reduction of solid organic matter, the facultative stage where the biochemical oxygen demand (BOD) is reduce, and the maturation stage where the bacterial load is reduced just before the waste is released into the environment. However the capacities of the wastewater plants in big towns have been out-grown by the population. The deplorable state of the treatment facilities poses a serious environmental hazard (Ntengwe, 2005). The Commercial/industrial wastewater is treated using various ways depending on the industry and management of its water usage. The degree of treatment before it is discharged depends on the kind contaminants involved and the process involved which may include: Cooling, management of the pH of the effluent -, decontamination from trace elements, heavy metals salts or other toxic substances, before discharge to the environment, respectively (Ntengwe, 2005.).

5. Wastewater use and disposal regulations

In Zambia, the use of wastewater in agriculture or aquaculture is illegal even though it is widely practiced in urban and peri-urban areas. The Zambian National Water Policy of 1994 specifies that water for irrigation should be fit for (1) human consumption and (2) not cause soil degradation (3) but enhance high crop yield.

Depending on the quality of the wastewater, it has been legally used in landscape and golf course irrigation, as cooling water in industry, recreational water, construction and dust control, wildlife habitat improvement and streams or ground water recharge.

Zambia Environmental Management Agency (ZEMA) has set standards for water quality for irrigation with respect to physiochemical and microbiological contaminants. In the absence of better information, WHO guidelines and standards for physicochemical parameters and faecal coliform are adopted.

6. Benefits and demerits of wastewater use

Wastewater is a reliable source of water and available all year round, permits higher crops yields, year-round production, and increases the range of crops that can be irrigated, wastewater contains large diversity of nutrients than any commercial fertilizer can provide, constitutes a low-cost disposal method and a land treatment system, under controlled conditions can also recharge aquifers through infiltration and can reduce costs to society, in view of reducing the fossil fuel in fertilizer production. In urban and peri-urban areas of Zambia, wastewater has been used for horticultural production. The approach has boosted agricultural production due to available water and nutrients in the wastewater thereby ensuring food security and family income for farmer's households (Mtonga, 2000).

The demerits of the use of the waste water include: its adverse impacts on health and environment depending on the treatment level, type of irrigation and local conditions; contains a variety of pathogens, that can survive on crops or in the soil, and pose health risks to farmers and consumers, and nearby communities; other contaminants e.g. chemical agents, salts and heavy metal can pose serious health and environmental risks (Kapungwe, 2013). In Zambia, the consumers of crops grown from untreated wastewater have been at high risks of contracting waterborne diseases such as cholera, diarrhoea and typhoid. Wastewater use in vegetable production has also been associated with outbreak of various epidemics (Mtonga, 2000).

7. Safe use of wastewater

Managing the risks in the use of wastewater is crucial and must be addressed from local and global perspectives. The 2006 WHO guidelines for safe use of wastewater, provides information on the assessment and management of risks associated with microbial hazards and toxic chemicals, in the use of wastewater in agriculture with the objective of **maximizing** the health and environmental benefits associated with the use of wastewater in agriculture and aquaculture and **prevention of the transmission** of disease and the exposure to hazardous chemicals. According to the guide, the management of risk should be facilitated by analysing the entire production cycle from waste generation to consumption of products from wastewater. Specific contexts may demand different interventions such as treatment of the wastewater to prevent contaminations, crop restriction to minimise health risks to consumers, waste application techniques aimed at reduction of contaminations, exposure control to exposed groups, disinfection and cooking to reduce exposure for product consumers, vector control to reduce exposure, immunisation for the exposed to prevent illness. The guidelines are designed to protect the health of the farmers and their families, local communities and product consumers. They are meant to be adapted for national, socio-cultural, economic and environmental factors.

The use of these guidelines should be encouraged to promote the safe use of wastewater. There is need for a robust policy and institutional framework to maximise opportunities and minimize risks related to the use of wastewater in agriculture in Zambia. Currently there are no outreach programmes to sensitise the farmer on the safe use of wastewater in Zambia. This scenario puts the consumer of these products at high risk of exposure to hazardous chemicals and to pathogens that can cause diseases.

8. Challenges of safe use of wastewater in Zambia

The challenges to effective use of waste water in Zambia include the following: Insufficient infrastructure to treat all wastewater; Inadequate technological capacity to treat the different kind of pollutants; Lack of qualified personnel and skills to deal with certain hazardous waste; Lack of policy focusing on reuse of wastewater as a resource for irrigation; Inadequate sensitisation to the public, farmers and politicians on safe wastewater use; Lack of innovative solutions suited to local needs and; Lack of the database on the existing knowledge and skills for the safe use of wastewater.

9. Conclusion

Wastewater is composed of organic matter, nutrients, inorganic matter, toxic chemicals and pathogens. In urban and peri-urban areas of Zambia, small holder farmers commonly use untreated wastewater as a source of irrigation water and plant nutrients for the high-value crops which they grow to secure their food and family income. However, unregulated use of wastewater also poses risks to human health and the environment. Zambia needs to promote the safe use of wastewater in order to protect the health of the farmers, their families and the other consumers of the products. The 2006 WHO guidelines for safe use of wastewater is a good starting point.

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Chapter 3. Sustainable Natural Resources Management and Utilization

Gender and Sustainable Natural Resources Management

Gillian Kabwe
Copperbelt University, Zambia, School of Natural Resources

1. Introduction

Gender refers to the economic, political and cultural attributes associated with being a man or a woman (Manfre and Subin, 2012; 3). It defines the characteristics, socio-cultural roles, and functions of men and women as they relate to each other within a specific socio-cultural context. Gender differs from sex, which refers to universal biological characteristics that differentiate males and females according to biology and reproductive characteristics. However, categorization based on gender allows for recognition of the social changes that occur in households and communities over time.

The term gender is often used to refer to women and leads to the misconception that women's issues are more important than men's. Gender analysis involves examining of roles, needs and preferences of both men and women (Manfre and Rubin 2012). When issues of gender arise and the focus is placed on women other than men, it is usually the recognition that women have fewer rights and opportunities. Through gender analysis, and by focusing on the group that is considered disadvantaged, we seek to identify the social norms that have created the inequality and also to find ways to redress imbalances.

Gender not only defines individuals, but is also an element of social relations. Gender relations denote the social constructs of how men and women interact (Manfre and Rubin 2012, 5), and also refers to social networks beyond kinship in communities, markets and political spaces.

2. Gender issues

Gender issues cut across natural resources management (NRM) and are shaped by who has what type of power which in turn provides the conditions of access to and distribution and control of property. Men and women have different roles based on the gender division of labour, and this also means that they have different priorities and realities and do benefit differently from natural resource use and management. Thus, men and women do not have equal or same rights over natural resources. It is therefore important to note the knowledge, skills and practices that both men and women contribute to the conservation, management and improvement of natural resources. It is necessary to look into both men's and women's roles, their knowledge, needs and contributions to NRM.

Gender roles and relations are dynamic as they evolve over time in response to changing circumstances, needs and interests. For instance gender roles and relations get renegotiated as forests grow, shrink, change and shift.

The concept of gender generally encompasses three different types of activity: Firstly, productive work, which includes tasks and responsibilities that produce goods and services for sale or consumption. This can include employment, self-employment and activities both in the formal and informal sectors; Secondly, reproductive or household work, which involves activities associated with maintaining the household, such as cooking, cleaning and caring for children, the sick or the elderly; Lastly, community work, which includes men's and women's contributions to community projects, such as community forestry groups, producer associations and water user groups. This can be paid or unpaid.

What is deemed appropriate work for men and women is continually shaped by power relations, social norms and changing socio-economic contexts. Many activities undertaken by women are perceived as extensions of their household responsibilities.

Notions about men's role as primary breadwinners and women's dominant role in households, and perceptions about men's and women's supposedly 'natural abilities', can limit women's opportunities for upward mobility or translate into unequal pay for similar work. Norms around mobility can affect where women gather forest products or the distances they can travel to trade. Women's disproportionate responsibility for household chores also has an influence on their ability to participate in community forestry meetings or invest in expanding their businesses. Women's groups face labour and time constraints that limit their ability to undertake regeneration activities, such as tree planting or clearing undergrowth.

3. Gender mainstreaming

Gender mainstreaming is a process through which efforts to integrate gender into existing institutions of the mainstream have been done in order to achieve gender equality and improve the relevance of development agendas. Such an approach shows that the costs of women's marginalization and gender inequalities are born by all. According to March et al (2005) "mainstreaming gender is both a technical and political process which requires shifts in organisational cultures and ways of thinking, as well as in the goals, structures, and resources allocation of international agencies, government, and NGOs". Gender mainstreaming is a strategy used to integrate gender concerns into every aspect of an organisation's or project's priorities and procedures (Reeves and Baden 2000), making gender concerns the responsibility of all and ensuring that they are integrated into all structures and all work. It is the transformational process for planning and implementing programmes, with due consideration of all stakeholders. It can take place at different levels of planning: project level; organisational level, etc.

4. Gender analysis

Gender analysis is a methodology for collecting, processing and examining information about gender (Reeves and Baden 2000). It is used to define gendered relationships and therefore positive and negative effects of interventions during analysing; designing; monitoring and evaluating. Gender analysis is a practical tool for examining the community diversity and the implications of this diversity for development. It focusses on activities and resources of both men and women, clarifying where they differ and where they complement each other. Such information is used to answer planning questions: Do the development objectives address the needs and priorities of both women and men?; Do these differ?; and Who wants to participate in each of the development activities planned – women? Men? Both? (Franzel and Kiptot, 2012) Gender analysis has increasingly revealed how women's subordination is socially constructed and therefore able to change as opposed to being biologically predetermined and static. Good gender analysis examines both men's and women's situations and identifies ways of drawing on the strengths of both to overcome the weaknesses of one or the other. What is more, it is also becoming difficult to ignore the constraints that men and boys face as their livelihoods are reshaped and changed by changing NRM.

4.1. Frameworks for gender analysis

Gender analysis frameworks are step-by-step tools for carrying out gender analysis. These help to raise questions, analyse information and develop strategies to increase women's and men's participation and benefits (GDRC, 2015). There are different types of frameworks that have been developed for use in gender analysis including: Harvard Analytical framework (Bastidas, 2001; World Bank, 2015); People-oriented framework; Moser framework; Capacities and vulnerabilities framework; Gender analysis matrix; Longwe Women empowerment framework; and Social Relations Approach.

5. Integrating gender in natural resource management

Integrating gender analysis into projects leads to better and more sustainable outcomes (Manfre and Rubin, 2012: xvi). Integrating a gender perspective is constrained by a lack of sex disaggregated data, lack of skills in gender analysis (FAO, 2007: 24) and an absence of political will to invest in and demand gender analysis at levels beyond the community (Manfre and Rubin, 2012: xvi). The following are the steps to follow in ensuring that gender is integrated in different programs (FAO, 1995): i. Recognise that there are gender-based differences in the roles, responsibilities and contributions of men and women and take these into consideration; ii. Recognise the value of men's and women's knowledge, skills and practices and their rights to benefit from the fruits of their labour; iii. Ensure sound and equitable policies to provide incentives for both men and women for sustainable use of natural resources; iv. Ensure fair and equitable sharing of benefits from their use; v. Ensure active participation of both men and women in planning and decision-making at levels; vi. Ensure recruitment of women professional staff in the NRM sectors at all levels; and vii. Encourage organisational development for gender equality to be practiced within local organisations, Non-Governmental Organisations (NGO), government agencies, and International NGOs, with the active and equal participation of men and women.

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Energy Production from Forest and Agricultural Solid Waste

Phillimon Ng'andwe[1], Peter Fushike[2] and Robby Kasubika[2]
Copperbelt University, School of Natural Resources, Zambia
[1] Department of Biomaterials science and technology,
[2] Department of Plant and Environmental Sciences

1. Introduction

Energy is involved in all life cycles and is essential in agriculture, industry and many productive activities such as elementary food chains. For example, plants need energy for growth to occur, cooking needs energy from biomass and food provides human body with energy to function. In view of the various demands, energy is a scarce resource and its rational use is necessary from social, economic and environmental point of view. Energy can exist in various forms including radiation, chemical (biomass), potential, kinetic, thermal, mechanical and electrical.

Forest and agriculture waste is one of the largest sources of biomass energy making 10% per cent of the world's total energy mix (IIED 2010). In developing countries the proportion of biomass energy in the national energy mix is even much higher (Ezzati, B. M et al. 2002; Kambewa and L.Chiwaula 2010; Mugo and Gathui 2010; Ng'andwe and E. Ncube 2011). For example, forest biomass is the main source of energy in Malawi accounting for 97% of total primary energy supply (Kambewa and L.Chiwaula 2010). Biomass energy provides 68% of Kenya's national energy requirements and it is expected to remain the main source of energy in the foreseeable future (Ezzati, B. M et al. 2002; Mugo and Gathui 2010). In Zambia it is estimated that 74% of cooking energy is from biomass energy, 16% from electricity and 10% coal (Ng'andwe and E. Ncube 2011).

There are various types of forest waste generated from land use change such as industrial development, agriculture, mining and construction (i.e. housing, roads, infrastructure etc). In general forest and agricultural waste, in form of wood, includes branches, maize cobs, leaves, tree tops, logs, firewood, bark etc., remain the largest biomass sources used in energy production. The most common forest waste is firewood gathered from forests and woodlands for household cooking and heating. Firewood is any wood based material that is gathered and used for fuel and is not usually processed. It is in form of a recognizable log or branch form and is different from processed forms of woodfuel such as charcoal, pellets or chips. On the industrial scale some sawmills have integrated use of mill waste that produces energy for steam or hot water boilers used for kiln drying of sawn timber. The largest source of energy from wood is pulping liquor or black liquor" a waste product from processes of the pulp, paper and paperboard industry.

2. Energy production

Humans have harnessed biomass-derived energy since the time when people began burning wood to make fire. In general, energy is produced by burning materials (feedstocks) derived from biological sources (e.g. logs, branches, twigs and various forms of agricultural waste) and such energy is often referred to as renewable bio-energy.

The industrial application of biomass for power generation has also re-emerged in recent years. Bioenergy is the energy extracted from the biomass. Biomass often refers to plants or plant-derived materials which are specifically called lignocellulosic biomass. Forest waste biomass, as a bioenergy source, can either be used directly via combustion to produce heat, or indirectly after converting it to various forms called biofuel which is a fuel that contains energy from geologically recent carbon fixation. Energy production from biomass to biofuel can be achieved through thermal, chemical, and biochemical processes.

2.1. Thermal chemical conversion

This process uses heat as the dominant mechanism to convert biomass into chemical form. The basic forms of thermal chemical conversion include combustion, pyrolysis and gasification. These forms of conversion differ principally by the extent to which the chemical reactions involved are allowed to proceed and mainly controlled by the availability of oxygen and conversion temperature. In combustion conversion methods, energy is generated by burning biomass such as fuel wood, sawdust, trims, etc. This type of energy is also known as dendrothermal energy. It is produced at household level where waste is abundant or trees for fuel wood grows rapidly as is the case in some tropical countries such as Zambia. In recent years the industrial application of thermal conversion technology has been the combined heat and power (CHP) generation and biomass co-firing with coal. This process generates both heat and electricity. For example, in Tanzania, such a plant has been operating using plantation grown timber while in Zambia the CHP plant is under way for using forest waste and coal.

2.1.1. Pyrolysis

Pyrolyis is a thermochemical breakdown of biomass at elevated temperatures in the absence of oxygen. The word is derived from the Greek –pyro "fire" and lysis "separating. Pyrolysis is usually the first chemical reaction that occurs when burning many solid organic fuels such as wood. In a wood fire, the visible flames are not due to combustion of the wood itself, but rather of the gases released during pyrolysis, whereas smoldering is the flame-less burning of solid residue called char or charcoal, left behind by pyrolysis. Charcoal is obtained by heating wood through complete pyrolysis resulting in carbonization. The heat generated by burning part of the wood and the volatile by-products pyrolyzes the rest of the pile while the limited supply of oxygen prevents the charcoal from burning. Charcoal production is one of the main economic activities in forest lands being converted to agriculture (Figure 1). Charcoal packed in 25 – 50kg bags is sold along roadside markets.

(a,·b)¤ (c)¶

Figure 1. Charcoal production chain in forest land converted to agriculture: (a,b) preparation of mounds (c) roadside markets

2.1.2. Gasification

Gasification is basically a thermochemical process which converts biomass materials (e.g. forest waste) into gaseous component. The technology uses the incomplete combustion which yields producer gas, containing carbon monoxide, hydrogen, methane and some other inert gases. This producer gas can be used for the production of biofuels or for electricity power generation.

2.1.3. Appliances

At household level various appliances range from three stone fire, furnace, cook stoves, fireplace, and camp. A wood-burning stove is a heating appliance capable of burning wood fuel and wood derived biomass fuel such as sawdust, pellets and charcoal. Most appliances consist of closed fire chamber (Fig 2), a fire brick based and adjustable air control or simply air vent (Kammen 2000). Most pyrolysing stoves regulate both fuel and air supply as opposed to controlling combustion of a mass of fuel by simple air regulation as in traditional stoves.

Figure 2. Sawdust stove at Rainland timber sawmill in Kitwe, Zambia: (a) sawdust stove (b) Pek pe charcoal brazier (c) three stone fire.

Today, biomass power plants for electricity generation have also emerged. The size of the biomass power plant is often driven by biomass availability and distance as transport costs of the feedstock play a key factor in the plant's economics. To make small plants of 1 MWel economically profitable such power plants are equipped with technology that is able to convert biomass to electricity with high efficiency.

3. Environmental issues - forest waste for energy production

Energy production from renewable forest biomass is often considered as a carbon neutral source of energy because the carbon dioxide released into atmosphere by using biomass is recovered again by growth of new biomass. In contrast, use of non renewable fossil fuels, releases "new carbon" which has been locked away in the form of hydrocarbon fuels in the earth's crust. Therefore, energy that is generated from forest biomass waste reduces the use of fossil fuels for energy.

4. Comparison of environmental issues with other energy sources

4.1. Solar energy

Solar energy is a renewable resource which is continuously supplied to the earth by the sun. Solar resources are available in most areas although some areas receive less sunlight than others depending on the climate and seasons. Technologies for production of power from solar are quite advanced. It is important to assess the environmental impacts by considering air emissions, water discharges, solid waste generation, land use and human health. For example emissions associated with generating electricity from solar technologies are negligible when compared to emissions produced from burning forest and agriculture waste. The primary environmental health and safety impacts involved in solar power equipment depend on how they are manufactured, installed and ultimately disposed off. For example fossil fuels may indirectly be used during the manufacturing process in vehicles and generators running on fossil fuels may be used during installation. In addition the production of photovoltaic wafers from silicon and other conducting materials may create small amounts of hazardous materials that must be handled properly to avert the risk to the environment or to people. However, photovoltaic cell production results in toxic chemical pollution including arsenic, gallium and cadmium if not properly handled.

4.2. Geothermal

Geothermal energy is continuously generated beneath the Earth's surface from extreme heat contained in liquid rock called magma, within the earth's core. When thus heat naturally creates hot water or steam it can be piped to the surface and then be used to turn steam turbines and generate electricity. Emissions from this energy source are negligible because no fuels are burnt. However, geothermal plants may pollute ground water when drilling the wells and extracting hot water if not properly handled. When compared to energy production from forest waste the high cost of geothermal plants becomes a limiting factor for underdeveloped countries.

5. Conclusion

There are various types of waste generated from land use change such as industrial development, agriculture, mining and construction that are used in the production of energy. Wood remains the largest biomass energy source in form of dead trees, logs, branches, twigs, leaves, tree roots and grass. In general all forest and agriculture waste are of biological origin and are biodegradable and can be converted to various forms of bioenergy using appropriate technologies.

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Environmental Impacts of Industrial Renewable Energy Production

Robby Kasubika[1] and Phillimon Ng'andwe[2]
Copperbelt University, School of Natural Resources, Zambia
[1]Department of Plant and Environmental Sciences,
[2]Department of Biomaterials science and technology

1. Introduction

The climate change debates and policies around renewable production continue to attract attention resulting in the intense scrutiny of energy demand and supply in many countries around the world. As consumption of primary energy increases, CO_2 emissions have correspondingly increased thereby impacting on the environment. Current debates have focused on reducing on fossil fuels and increasing on renewable energy. Renewable energy sources are those which are replenished at a rate greater than they are consumed and include solar energy, some forms of biomass, geothermal, hydropower and wind (Johnson, 2009, Ng'andwe and Ncube, 2012). Fossil fuels such as coal, oil, and natural gas have more negative impacts than renewable energy sources with regards to polluting air and water, damage to public health, wildlife and habitat loss, water use, land use, and global warming.

The exact type and intensity of environmental impacts associated with producing power from renewable sources on an industrial scale varies depending on the technology used, the geographic location, and a combination of a number of other factors. The current and potential environmental impacts associated with each renewable energy source need to be understood in order to effectively avoid or minimize these impacts as they become a larger portion of national electric supply mix. In this article we present highlights of environmental impacts of industrial energy production of electricity from biomass, geothermal, hydropower, solar and wind.

2. Biomass for electricity

Energy production from biomass such as forest, agriculture and municipal waste involve the combustion of the feedstock to generate electricity and thus share some similarities with fossil fuel power plants. However the emission levels are not identical since the feedstock of biomass plants can be sustainably produced and they are also renewable while fossil fuels are unsustainable and are non-renewable (Ng'andwe et al., 2015). Sources of biomass feedstock for producing electricity are diverse; including forest and agriculture waste, energy crops (like switch grass), wood fuel and urban sewage sludge and manure.

The most common biomass in the developing countries is from plants which obtain energy from the sun during growth by converting solar energy into chemical energy in the process of photosynthesis. This energy is released as heat energy when the plant material is burned. The heat released from this process is used to heat water into steam to turn a steam turbine to create electricity or gasified to producer gas which is then used for electricity generation (Ng'andwe et al., 2015).

Biomass is generally considered as a renewable energy source because the CO_2 emitted from its combustion, is offset by the CO_2 absorbed by the plant during its life cycle to produce biomass (Kruger, 2006). The chemical composition of biomass is also low in sulphur, resulting in lowered SO_2 emissions over fossil fuels. Some studies have also shown that the carbon sequestration capability of mature trees is much greater than that of the resulting regeneration from a cleared area (Johnson, 2009). In addition, they argue that the relatively instantaneous release of carbon stored in wood biomass has a significantly larger impact on global warming than the gradual decomposition process that would occur in a forest (Johnson 2009).

2.1. Air emissions

Biomass power plants emit nitrogen oxides and a small amount of sulfur dioxide. The amounts emitted depend on the type of biomass that is burned and the type of generator used. Although the burning of biomass also produces carbon-dioxide, the primary greenhouse gas, it is considered to be part of the natural carbon cycle of the earth.

2.2. Water resource use

Biomass power plants require the use of water for steam production and for cooling. If the power plant obtain water from a lake or river, fish and other aquatic life can be killed, which then affects those animals and people that depend on these aquatic resources

2.3. Water discharges

As is the case with fossil fuel power plants, biomass power plants have pollutant build-up in the water used in the boiler and cooling system. The water used for cooling is much warmer when it is returned to the lake or river than when it was removed and may affect the flora and fauna. For example, pollutants in the water and the higher temperature of the water can harm fish and plants in the lake or river where the power plant water is discharged.

2.4. Solid waste generation

The burning of biomass in boilers creates a solid waste called ash that must be disposed properly, if not would harm the environment.

2.5. Land resource use

Biomass power plants, much like fossil fuel power plants, require large areas of land for equipment and fuel storage. Biomass grown for fuel purposes requires large areas of land and, over time, can deplete the soil of nutrients.

3. Geothermal energy

Geothermal energy is the heat from the Earth which ranges from the shallow ground to hot water and hot rock found some meters beneath the Earth's surface, and even deeper to the extremely high temperatures of molten rock called magma. This source of energy is clean and sustainable and it is continuously created beneath the earth's crust from the extreme heat contained in liquid rock (called magma) within the Earth's core. The high temperature and pressure in Earth's core cause some rock to melt and solid mantle to behave plastically, resulting in portions moving upward since it is lighter than the surrounding rock. Rock and water is heated in the crust, sometimes up to 370°C and thus creates hot water (e.g. hot springs) or steam, it can be piped to the surface and then used to turn a steam turbine to generate electricity. Geothermal energy exists in many parts of the world (Fridleifsson et al., 2008), however, it is not easy to extract unless it is close to the surface. Drilling and exploration for deep resources is very expensive and many countries do not have the technology to tap into these resource.

3.1. Air emissions from geothermal

Emissions associated with generating electricity from geothermal technologies are negligible because no fuels are combusted. According to Fridleifsson, et al (2008) emission from geothermal power plants in high-temperature fields is about 120 g/kWh (weighted average of 85% of the world power plant capacity). They estimated that if Geothermal heat pumps driven by fossil fuelled electricity are used this result in the CO_2 emission reduction of at least 50% compared with fossil fuel fired boilers and if the electricity that drives the geothermal heat pump is produced from a renewable energy source, such as hydropower or geothermal energy the emission savings could be up to 100%.

3.2. Water resources use

Geothermal power plants usually re-inject the hot water that they remove from the ground back into wells. The CO_2 emission from low-temperature geothermal water is negligible or in the order of 0-1 g CO_2/kWh depending on the carbonate content of the water. Geothermal power plants can possibly cause groundwater contamination when drilling wells and extracting hot water or steam but this type of contamination can be prevented with proper management techniques.

3.3. Land resource use

Geothermal power plants typically require the use of less land than fossil fuel power plants. However, if water is not re-injected into the ground after use to maintain pressure underground, it may cause sinking of land at the surface.

4. Hydropower

The energy derived from gravitational force of falling water or fast running water is called hydropower and electricity generated is called hydroelectricity. It is a form of renewable energy widely used and accounting for 16% of the global electricity generation. Globally, small, medium and large-scale hydroelectric dams continue to be built with the increasing demand for renewable energy. The environmental impacts include those related to water and land use. The dam size created by a hydropower project varies widely, depending on the size of the hydroelectric generators and the topography of the land. For example hydropower plants in flat areas tend to require much more land than those in hilly areas.

4.1. Land use impacts

Flooding land for a hydroelectric reservoir has an extreme environmental impact: it destroys forest, wildlife habitat, agricultural land, and scenic lands. In many instances, such as Zambia (by then Northern Rhodesia) the communities had to be relocated to make way for reservoirs. The creation of the Kariba dam in Zambia and Zimbabwe forced about 57,000 people living along the Zambezi River in both countries. Some people were relocated to less-productive, problem-prone areas, some of which have been so seriously degraded within the last generation that they resemble lands on the edge of the Sahara Desert.

4.2. Wildlife impacts

Even though water reservoirs in hydro dams are used for multiple purposes, such as agricultural irrigation and recreation, such developments have a major impact on aquatic ecosystems such injury to fish and other organisms by turbine blades. Since water in the reservoir is usually more stagnant than in rivers, the reservoir will have higher than normal amounts of sediments and nutrients, which creates an conditions for excess of algae and other aquatic weeds to grow such as the famous Kafue weed in Zambia. In addition, since water is lost through evaporation in dammed reservoirs at a much higher rate than in flowing rivers, aquatic life would be affected. The Kariba Dam controls 90% of the total runoff of the Zambezi River, thus changing the downstream ecology dramatically and threatens animals downstream whenever the gates are opened to control water levels in the Dam (Figure 1).

Figure 1. The Kariba Dam of Zambia and Zimbabwe opened in 1959

On the other hand if too much water is stored behind the reservoir, segments of the river downstream from the reservoir can dry out as water levels downstream drop thereby affecting harmfully animal and plant life.

5. Solar

Solar energy is a renewable resource because it is continuously supplied to the earth by the sun hence it is sustainable and clean. According to Lercher (2008) there is significant potential in this source of energy since the total solar radiation intercepted by Earth is in the order of 8000 times greater than the human global primary energy demand. Currently, two methods of harnessing solar energy exist: concentrated solar power (CSP) and solar photovoltaic (PV), (Letcher, 2008, C.Hung, 2010). CSP concentrate the sun's rays with mirrors or other reflective devices to heat a liquid to create steam, which is then used to turn a generator and create electricity while PV uses cell arrays to capture solar energy and convert it into direct current electricity (Letcher, 2008).

5.1. Air emissions

Emissions associated with generating electricity from solar technologies are negligible because no fuels are combusted. The primary environmental, health and safety issues involve how solar equipment is manufactured, installed, and ultimately disposed off. Energy is required to manufacture and install solar components, and any fossil fuels for this purpose will generate emissions.

5.2. Water and solid waste discharges

Solar technologies do not discharge any water while creating electricity and do not produce any substantial amount of solid waste while creating electricity. The production of photovoltaic waters creates very small amounts of hazardous materials that must be handled properly to avert risk to the environment or to people.

5.3. Land resource use

Photovoltaic systems require a negligible amount of land areas because they are typically placed on existing structures. In contrast, solar-thermal technologies may require a significant amount of land, depending upon the specific solar-thermal technology used. Solar energy installations do not usually damage the land they occupy, but they prevent it from being used for other purposes.

5.4. Human health

Photovoltaic cell production results in toxic chemical pollution, including arsenic, gallium, and cadmium if not properly handled. Arsenic and cadmium can pose a serious problem in areas subject to dust abrasion, such as deserts. Even silicon dust might pose a health problem. Injuries and deaths may occur during construction and maintenance since thermal solar plants can set on fire releasing toxic smoke.

6. Wind

Wind is created because the sun heats the Earth unevenly due to the seasons and cloud cover. This uneven heating, in addition to the Earth's rotation causes warmer air to move toward cooler air. Wind energy is harnessed using wind turbines on land or at sea or offshore. Kinetic energy from the wind is converted to mechanical energy using a gearbox. The majority of modern wind turbines consist of three-bladed rotors. The rotors are connected to a low-speed shaft. In order to increase the speed of the shaft, the gearbox increases to shaft speed to match the rotational speed of an induction generator (C.Hung, 2010).

6.1. Air emissions

Emissions associated with generating electricity from wind technology are negligible because no fuels are combusted. However according to Hung (2010) the most significant areas of material flow lie indirectly in the metals used which are related to the construction of the turbine itself, which is heavy in concrete/cement and metal. Fuels also play a considerable role, likely attributable to the energy intensive materials such as steel and aluminum.

6.2. Water resource use

Wind turbines in areas with little rainfall may require the use of a small amount of water. If rainfall is not sufficient to keep the turbine blades clean, water is used to clean dirt and insects off the blades so that turbines performance is not reduced.

6.3. Land use

While wind farms require a large area to produce a commercially viable quantity of electricity (Letcher, 2008, C.Hung, 2010) very little of the land – approximately 3% – is actually occupied by the turbines. As a result, most of the land the wind farm occupies may still be used for grazing or tillage (C.Hung, 2010).

7. Conclusion

The use of renewable energy is gaining momentum as countries position themselves to reduce emissions from fossil fuels. It is particularly suitable for developing countries especially in rural and remote areas where transmission and distribution of energy generated from fossil fuels and hydropower can be difficult and expensive. The advantages of switching to renewable energy out-weigh the negative environmental impacts associated with industrial renewable energy production. In many cases technology, policies, standards and systems have been developed to mitigate such impacts.

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Tämän selvitysraportin tavoite on koota yhteen tietoa liikkuvien ja kotiin vietävien palvelujen tilanteesta maakunnassa sekä kerätä tietoa tuottajien ja asiakkaiden näkemyksistä niiden kehittämisestä. Sen lisäksi raporttiin on kerätty tietoa muualla Suomessa kehitellyistä hyvistä käytännöistä ja ratkaisuista.

Selvitysraportti kokoaa yhteen myös menossa olevaan SOTE-uudistukseen liittyvää lähi- ja etäpalveluista käytävää keskustelua. Liikkuvat palvelut on tärkeä osa siinä keinovalikoimassa, jota tulevaisuudessa hyödynnetään sosiaali- ja terveyspalvelujen saatavuuden ja saavutettavuuden turvaamiseksi.

Raportin lopputulema on, että reuna-alueet ja maaseutu voidaan pitää asuttuna vain, jos palvelujen saatavuus on varmistettu. Tärkeää on myös ymmärtää, että kyse on laajasta kokonaisuudesta. Liikkuvia palveluja ei tule käsitellä erillään muusta palvelujen kehittämisestä eikä aluekehityksestä.

Alueiden palvelujen turvaamisen lähtökohta on alueen tarpeiden täsmällisempi analyysi ja lähipalveluiden sekä liikkuvien palvelujen parempi integraatio. Myös uuden teknologian käyttöönotto ja monitoimijuuden parempi hyödyntäminen palvelujen tuottamisessa voivat taata palvelujen säilymisen ja saatavuuden haja-asutusalueillakin.

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