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Sustainable Natural Resource Management, a Global Challenge of This Century

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1. Introduction

Food security, environment management and poverty alleviation are main factors contributing the complexity of natural resource management. This chapter intends to show the scope of these challenges in the worldwide and to propose some strategies for managing these challenges or complexities. In definition, food security exists when all people, at all times, have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 2011a). The world must feed 9.8 billions people by 2050. The challenge of food security is not a new story, but it is still one of the main crises of the world. The food crisis and famine in the Horn of Africa, especially Somalia, has just happened in 2011. Millions of people in Africa and Asia are under threat of famine. This may not be because of only food shortage, but due to lack of capability of some areas to provide food to their people. The President of the International Fund for Agricultural Development (IFAD) in the World Food Day 2011 pointed out that "As long as there is even one person dying of hunger we must do everything within our power to prevent it. The latest crisis in the Horn of Africa shows the terrible human cost of neglect, both of agriculture and rural areas. Droughts are not preventable but famines are" (FAO, 2011b).

Agriculture and natural resources are viewed to be not only the context of food production, but they are the main resources of small-scale rural livelihoods. National resources are viewed as natural capitals of rural households and communities' livelihoods in the framework of Sustainable Rural Livelihood (Fabricius, Koch, Magome, & Rurner, 2004). Despite the importance, the interaction of several factors has limited the capability of agriculture and has threatened natural resources. Urban population and consumers are growing, the pressure on natural resources is increasing and limited public support is available to natural resource management. Factors such as deforestation, land degradation and water scarcity, especially as the result of human activities have adversely affected the productivity of all agricultural and natural ecosystems.

The year 2011 was named as the International Year of Forests by the UN, which stresses the crucial importance of sustainable management of forests worldwide. The FAO (2010) has estimated that approximately 13 million ha forest is lost or converted to other land uses a year. This organization has indicated that deforestation accounts for nearly 20 percent of

global greenhouse gas emissions. It also costs the world economy up to five billion dollars every year. According to the the Centre for International Forestry Research (CIFOR), the main causes of deforestation are infrastructure development, agricultural development, and human settlement, for example mining, charcoal production, fire, road building and pasture ranching. These are directly or indirectly related to governments' policies and interventions.

Natural resources degradation may also increase the vulnerability of rural households, which may, in turn, increase their overpressure on natural resources. A sustainable agriculture and Natural Resource Management (NRM) through multi-paradigmatic approaches can be utilized for a better understanding and managing these complexities, which involve and link different paradigms of social actors or their knowledge. This systemic linkage depends on the willingness of these stakeholders.

2. Main challenges

2.1 Poverty and food security

Agriculture and natural resources confront significant challenges in food security and production, environment management and poverty alleviation in this century. According to the UN (2006), the percentage of the developing world's population living in absolute poverty with an income of less than one dollar a day has dropped from 28 percent (1.2 billion) in 1990 to 19 percent (1.07 billion) in 2002 (Fig. 1). This decrease was mostly related to efforts in Asia where this population dropped by nearly a quarter of a billion. However, in Sub-Sahara Africa, 100 million were added to the population living on less than $1 a day between 1990 and 2001 (UNDP, 2005). The poverty analyses also show that another 1.5 billion people live on poverty with $1-$2 a day, which has an increasing trend, estimating to be 1.7 billion people by 2015 (UNDP, 2005). Therefore, 40 percent who lived on less than $2 a day faced the reality or the threat of extreme poverty. According to the World bank (2011), the poverty in South Asia and Sub-Saharan Africa is much worse than any other region of the world (see Fig. 2).

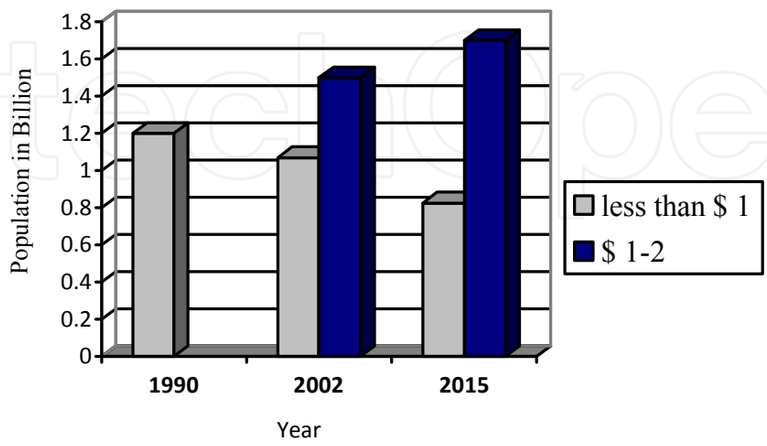
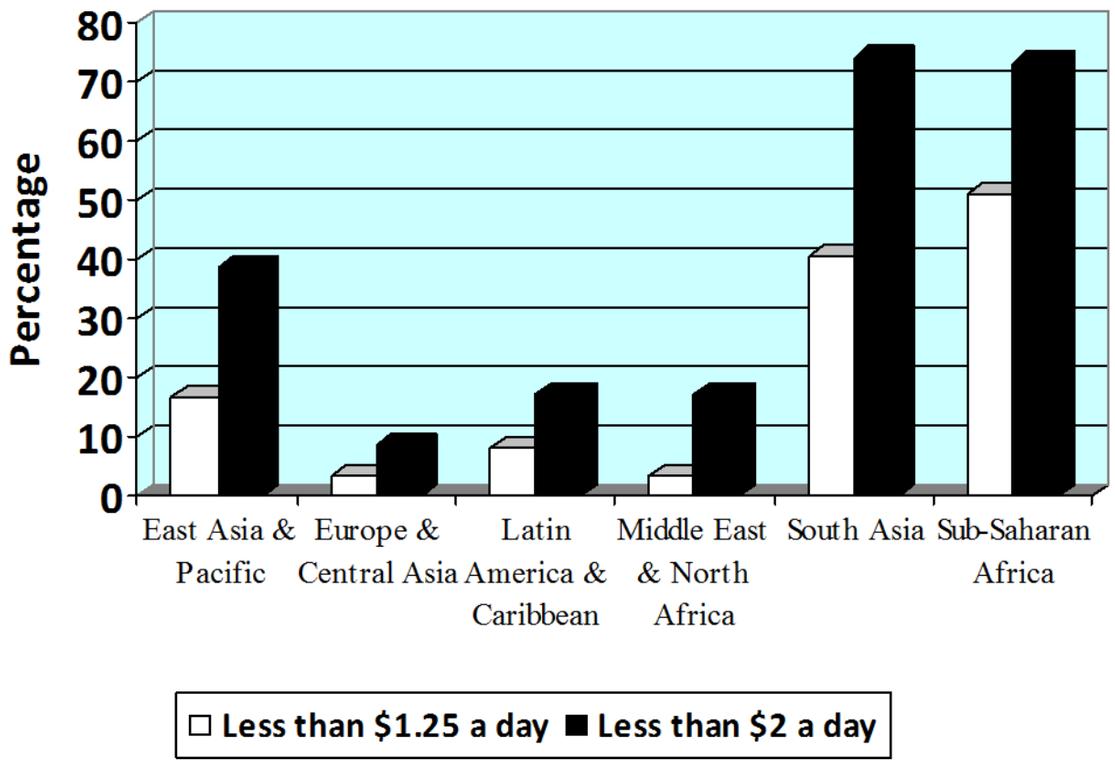


Fig. 1. Population living in less than one USD and 1-2 USD worldwide



Source: Adapted from World Bank (2011).

Fig. 2. Percentage of the world population (except the North America) living in less than $1 and $2

Nearly three quarters of the poor live in rural areas and almost all depend directly or indirectly on agriculture for their livelihoods; therefore, lands, animals, forests, pastures and fish stocks are their main livelihood resources (The World Bank, 2000; UNDP, 2005). Their economic activities are small scale with low productivity of labour and some of them are landless. UNDP (2005) estimates 826 million people will live on $1 a day (14 percent of developing countries' population) and 1.7 billion on $1-$2 a day by 2015, if the current patterns of growth and distribution continue.

Statistics also show that despite the decline of the proportion of the population with chronic hunger, the global total has increased from over 800 million people in 1990 (The World Bank, 2000) to an estimated 824 million (in more than 80 low income developing countries) in 2003 (United Nations, 2006). Malnourished population has also been estimated differently between 2 billion, who suffer from micronutrient deficiency (Hine & Pretty, 2006) to 3.7 billion based on the World Health Organisation's report in 2004 (Pimentel *et al.*, 2006). The occurrence of malnutrition has been due to scarcity or high cost of food or the interfere of political unrests and it causes human suffering and death as well as increasing vulnerability to different diseases (Pimentel *et al.*, 2006).

Whilst overall food production has increased over the last two decades, per capita availability of food, especially cereals has declined. Moreover, the global population is

expected to exceed 8.9 billion by 2050 (FAO, 2006a). So more food, water, energy and jobs are needed to maintain life and health at an acceptable level, in which agriculture must be able to double food production by that time.

Increased production by small farmers within food deficit countries could enhance supplies, reduce rural poverty and improve household security. This requires agricultural intensification, combination of technological innovation, improved farming skills and other necessary inputs. However, it is not clear to what extent small farmers can access these requirements.

On the other hand, consideration of environmental sustainability may restrict the ability to increase productivity. Expanding intensification has often had adverse environmental consequences, e.g. deforestation, soil nutrient depletion, falling ground water tables, chemical and waste pollution, expanding deserts, rising CO2 levels, deteriorating grasslands, loss of biodiversity and so forth (Scherr, 1999 ; World Bank & FAO, 2000; Brown, 2005; Dumanski, 2006;).

2.2 Land degradation and soil erosion

The interaction of several factors has limited the capability of agriculture to produce food and has threatened natural resources. Among them, deforestation and land degradation, especially as the result of human activities have globally adversely affected the productivity of all agricultural and natural ecosystems such as croplands, rangelands and forests.

The data available in 1990s shows 14,800 million hectare (13 percent of total cropland area of the world) is affected to some extent by degradation and 84 percent of these degraded land is affected by wind and water soil erosion (Wild, 2003). Loss of soil vegetative cover along with topography, especially in developing countries, is one of the main reasons for soil degradation and is intensified by extensive removal of forests, overgrazing rangelands, cultivation in sloping lands and collecting biomass from ground cover (Wild, 2003; Pimentel, 2006). These activities leave the soil exposed to rain and wind forces to degradation. According to Table 1, about 1.9 billion hectares of land worldwide are affected by human-induced soil degradation (United Nations, 1997; Lal, 2001). This is equal to 15.1% of total land area, though this percentage is different in different regions.

In another global assessment commissioned by the UNEP, it was estimated that 11% of the earth's vegetated land has been moderately or strongly degraded, implying that productivity has been significantly reduced. The extent of degradation is estimated to be particularly high in Africa, where about 3.2 million km^2 are moderately or strongly degraded. In 1998, it was also estimated that about 21 million hectares (210,000 km^2) of cropland became so degraded that crop production becomes uneconomic (Von Baratta, 1998).

According to Pimentel (2006), three quarters of soil erosion worldwide comes from agricultural production where croplands and rangelands have less vegetative cover and a wide area has been converted from forests to croplands. In the early 1990s, about 80 percent of agricultural lands in the world had severe or moderate soil erosion. It has been estimated that croplands producing 30 ton/ha a year have had 75 times the soil erosion experienced by natural ecosystems. In the last four decades, over 30 percent of the world's arable land

has become unproductive and an estimate of 10 million ha is abandoned each year. Since humans started farming, about two billion hectare has been abandoned and 1.5 billion hectare, currently under cultivation, is under threat (Pimentel, 2006). Soil erosion has been reported from 13 tons/ha/ year in the US to 40 tons/ha/year in China. These figures have been reported by many scholars and researchers worldwide.

Although water and wind soil erosion is a serious problem worldwide, it is more serious in developing countries of Asia (663× 10^6 ha), Africa (413× 10^6 ha) and South America (Table 1) where economic and environmental impacts are debatable (Lal, 2001). In these areas, small farmers in marginal and steep lands with poor soil quality are more vulnerable. In US and European countries, soil erosion in croplands is about 10 ton/ha-year, but it is still more than natural state of soil erosion in that 90 percent of US croplands lose their soil faster than normal trend. Soil erosion in rangelands of the US has been 6 ton/ha year, but more than half of the rangelands have had to some extent overgrazing that increase erosion rate in these lands (Pimentel, 2006).

Although rangelands have less soil loss than croplands, there is a high rate of soil erosion in over 50 percent of the world's rangelands, especially in overgrazed lands. Forest areas which have been cleared for crop production or pasture are highly susceptible to soil erosion (Pimentel, 2006). Soil erosion also has on-site and off-site effects on biodiversity loss, water storage capacity decline, intensifying water run-off and carrying vital plant nutrients. Other effects are sedimentation, shortening lifetimes of rivers and reservoirs, overflowing rivers due to deposits, reducing vegetation and soil biota and global warming (Wild, 2003; Morgan, 2005; Pimentel, 2006; Dumanski, 2006). However, more research is needed to develop effective soil and water conservation practices and farmers should be motivated and given enough incentive to implement these projects.

Regions	Total land area (10^6 ha)	Human-induced soil degradation		Soil erosion (10^6 ha)	
		(10^6 ha)	%	Water	Wind
Africa	2966	494	16.7	227	186
Asia	4256	748	17.6	441	222
South America	1768	243	13.7	123	42
Central America	306	63	20.6	46	5
North America	1885	95	5.0	60	35
Europe	950	219	23.1	114	42
Oceania	882	103	11.7	83	16
World	13013	1965	15.1	1094	548

Source: Adapted from Lal (2001)

Table 1. Human-induced soil degradation in different regions of the world in 1991

2.3 Forest degradation

According to FAO (2006b and 2010) global assessment in 2005 and 2010, total forest area was estimated to be almost 4 billion hectares (30 percent of total land). Other wooded land area was 1,376 million ha and other land with tree cover was estimated 76 million ha. This forest area corresponds to 0.62 ha per capita unevenly distributed (62 countries mostly located in arid or semi arid areas had less than 0.1 ha of forest per capita). Despite considerable progress towards conservation and afforestation, trend analysis of forest area still shows a high rate of deforestation between 1990 and 2010. Total deforestation during 1990-2010 was 13 million ha a year, but net global loss of forest was 8.3 million ha a year in 1990-2000, 7.3 million hectare a year in 2000-2005 and 5.2 million hectare per year in 2000-2010). This was due to conversion of forests to agricultural land and lack of enough effort for forest planting, landscape restoration and natural expansion of forests. South America and Africa had a decreasing trend, whereas Europe, North America, Asia and Oceania have had an increasing trend in forest area during 2000-2010.

This assessment also estimated that the total global growing stock for forests was 110 m^3 per hectare in 2005. This showed a slight overall downward tendency since 2000 (except Europe which showed an increase in growing stock). The world's forests store 283 Gigatonnes (Gt) of carbon in their biomass and 638 Gt in their ecosystems including soil, showing they contain more carbon than the entire atmosphere. It was estimated that carbon stocks in forest biomass decreased annually by 1.1 Gt in this period in Africa, Asia and South America, while it increased in other areas.

All these challenges need sustainable strategies in NRM and agricultural and rural development (Pretty, 1998; World Bank & FAO, 2000; McLuskey, 2001). Not only does production face a higher number of demands, but environmental and socio-economic factors raise limits and new concerns that create a complex situation. Some global and national conventions also suggest ways to carry out a sustainable approach for natural resources and land management. Examples are the UN Convention to Combat Desertification, United Nations Framework Convention for Climate Change (UNFCCC), Kyoto Protocol for reducing GHG carbon emission (through soil and forest conservation), international and national water resources conservation and Millennium Development Goals (Dumanski, 2006; FAO, 2006b; United Nations, 2006).

Past efforts on sustainable agriculture and natural resources have been inadequate compared to the scale of deforestation and land degradation. One element of this neglect is related to research and understanding about the threat. According to International Food Policy Research Institute (IFPRI), there is incomplete information on how to meet food needs whilst reducing poverty and protecting the environment (Scherr, 1999). While most ecosystem changes in the recent past have been the result of human activities for food, water, timber, fibre and fuel, more focus has been on scientifically researching the physical or natural aspects of this problem. Socio-economic factors related to sustainable land management have been much less analysed (Dumanski, 2006). Subjects that need more research are impact of investment on land management, institutional and policy barriers, access to markets, knowledge and information dissemination/facilitation, decision making process and support, collective advocacy work, long term financing and other required services.

3. Managing challenges

Managing these challenges depends on a comprehensive understanding of the relevant factors influencing the crisis in natural resources and the capability of agricultural productivity. Many studies are available concerning climatic and physio-topographic factors in NR situation and degradation as well as agricultural productivities, but not much knowledge is available on the relationship of these factors with human activities.

According to FAO (2011b), effective strategies and tools exist that farmers can employ to increase their resilience to climatic and other shocks. "Long-term investment in agriculture -- not only from international donors but from the countries themselves -- is the key to ensuring that such tragedies do not happen again."

All the challenges mentioned in the above sections need sustainable strategies in NRM and agricultural and rural development at global, national and local levels. Despite several global and national conventions, past efforts on sustainable NRM and agriculture in the world have been inadequate compared to the scale of deforestation and land degradation. In a sustainable perspective, it is argued that sustainable growth is possible in currently unimproved and degraded areas or what Chambers and Conway (1991) and Chambers (1997, 2005) refer to as complex, diverse, risk-prone agriculture, while at the same time regenerating natural resources. Pretty (1995 & 1998;) maintains that sustainability itself is a complex and contested concept. Sustainable agriculture is not a simple model or package to be imposed on farmers, especially with the idea of environment or natural resource conservation, but it is more a process for learning to fulfill all its criteria.

Most policies of the development plans in the last decades have focused on the agricultural production increase in order to provide required food for the increasing population. The existing policies and strategies have been mostly either production-oriented or conservation-oriented. This has caused a lack of integration between these two issues as well as limited improvement of small-scale farmers' livelihoods. These programs have mostly been developed using the reductionist or systematic paradigms, which provide few opportunities for the rural communities' active participation (Karamidehkordi, 2007). Production-oriented programs have covered mainly the rich or moderate resource farmers, mostly through a transfer of technology approach. In conservation programs, rural people dependent on natural resources have been considered as main factors responsible for degradation rather than social actors in development who can express their voice and share their knowledge in their management.

The knowledge and capability of rural people to participate in sustainable NRM need to be assessed and improved. It is also essential to know to what extent the supportive knowledge and information systems are effective to facilitate innovation organization. Using systems thinking approaches may help these stakeholders manage these complexities and facilitate sustainable NRM and agriculture to deal with main challenges.

4. Conclusion and recommendations

Sustainable strategies are required in managing the complexities related to utilizing natural resources, agriculture, and rural development at global, national and local levels. The world

needs to employ approaches to let people understand these challenges much more comprehensively and holistically than any other time. It is essential to use systems thinking to help us think and learn collectively how to manage these complexities and challenges. We need to employ and facilitate networking and collaborating among social actors mainly, agricultural researchers, natural resource conservationists, rural and nomadic communities, extensionists, agricultural businesses, NGOs, policy makers and markets. Enhancing information exchange networks and establishing multi-actor platforms can facilitate these approaches, which make a link between different studies, paradigms, experiences, worldviews and methodologies. The implication of these multi-paradigm approaches is not only understanding technological and bio-physical realities of an agro-ecosystem such as a watershed, but understanding and managing relationships, interventions, policies, participations, investments and governance methods.

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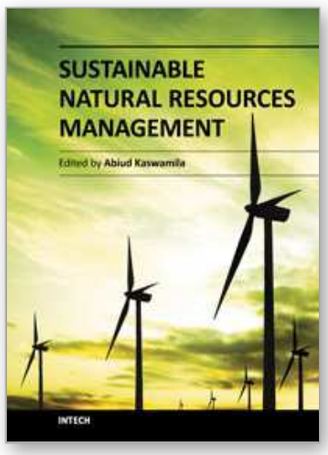

Sustainable Natural Resources Management

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Natural resources conservation is one of the dilemmas currently facing mankind in both developed and the developing world. The topic is of particular importance for the latter, where the majority depend on terrestrial ecosystems for livelihood; more than one billion people live in abject poverty earning less than a dollar per day; more than 3.7 billion suffer from micronutrient deficiency and more than 800 million suffer from chronic hunger. Population increase, resource use conflicts, technological advancements, climate change, political doldrums, and unsustainable use and harvesting of resources have all put more pressure on natural resources leading to land degradation and poverty. To achieve a win-win situation, we need to change our mindset by thinking outside the box through advocating integrated and holistic approaches in managing our natural resources. This book presents a variety of sustainable strategies and/or approaches including use of GIS and Remote Sensing technologies, decision support system models, involvement of stakeholders in major decisions regarding use of natural resources, community level initiatives, and use of surveillance and monitoring mechanisms.

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