The interactions of human mobility and farming systems and impacts on biodiversity and soil quality in the Western Highlands of Cameroon

Tankou, C.M.

Author: Tankou, Christopher Mubeteneh
Title: The interactions of human mobility and farming systems and impacts on biodiversity and soil quality in the Western Highlands of Cameroon
Issue Date: 2013-12-12

1 General Introduction

1.1 Introduction

Human mobility takes a wide variety of forms from permanent migration between regions to diurnal movements such as commuting to work (Parnwell, 1993). These movements generate flux in population numbers and carve out pathways in time and space. Capturing these movements is critical to understanding the use of space and place as mobility almost inevitably affects people's differential access to social, economic and human resources (De Haas, 2009). Human beings therefore, are constantly on the move, transgressing social and spatial boundaries to expand their capabilities and entitlements in order to improve their welfare (Sen, 1999). Movements in relation to rural land use may have a widely diverging impact on the biodiversity and farming systems in the rural milieu, depending on the type and causes of the movement and the interactions with farming systems (Quinn, 2006; Stark & Taylor, 1989; Taylor, 1999). While the consequence of migration on national development in "sending" countries is generally the loss of the highly skilled labour force ('brains'), the loss of an agricultural local workforce ('brawn'), affects the standard of living and farming systems in rural areas of the "sending" country. The departure of young, able-bodied men and women from rural areas (Lewis, 1986) has been typically blamed for causing a shortage of agricultural and other labour, depriving areas of their work force and thus affecting farming systems (Lipton, 1980; Rubenstein, 1992; Taylor, 1984), which can disrupt economic production and lead to a decline of productivity in the agricultural and other traditional sectors (De Haas, 1998). The causes and course of intra-rural and rural-urban mobility reflect the effects of contrived economic policies that have systematically marginalised the rural sector. Governments' neglect of this sector fuels unemployment, low productivity, poverty and rural exodus. Studying human mobility and land use as discrete subjects of inquiry precludes a comprehensive understanding of the process by which rural households attempt to maximize resource access. If we are interested in understanding the variables that influence land use change, we must inquire not only how people are managing land, but why they come to be there in the first place and hence the genesis of certain patterns of mobility. Studies have demonstrated that people from drier regions are more likely to move temporarily and permanently to other rural areas (rural-rural movement), compared to people from wetter areas and that long-term movement seems to be less related to environmental conditions than short-term moves (Henry *et al.*, 2004). In general, scarcity of land influences the rural-rural mobility of farmers from land-deficit to land-surplus areas (Swindell, 1984). Fragmented, unproductive landholdings, climate change and poor incomes compel farmers to seek more fertile land, land with special advantages (such as land close to streams that can be used for irrigation during the off-season), wage labour or non-farm activities (Pike & Rimmington, 1965; Pike, 1968).

Rural-urban and rural-rural mobility affect both rural and urban change, and influence resource use and management (Potts, 2006). Urban-rural and intra-rural linkages include flows of people, of goods, of money and of information, as well as other social transactions that are central to social, cultural and economic transformation. Within the economic sphere, many urban enterprises rely on demand from rural consumers, while access to urban markets is often crucial for agricultural producers (Kydd & Christiansen,1982; Kalipeni, 1992). In addition, a large number of urban-based and rural-based households rely on the combination of agricultural and non-agricultural income sources for their livelihoods. This may involve straddling the rural-urban divide from a spatial point of view involving movement between urban and rural areas, or from a sectoral point of view engaging in agriculture in urban centres or in non-farm activities in rural areas (Tacoli, 2002). A traditional movement of population in Africa which is worth mentioning concerns the sahelian population, whose mobility is dictated by vagaries of climate and poverty (De Bruijn & van Dijk, 2003). Their mobility which is a typically rural-rural type, is southbound in search of favourable grazing grounds for their cattle due to the limited and irregular rainfall pattern of the zone and also due to the uneven economic development of the sahelian and coastal countries in west Africa which favours the movement of Fulbes to the coast in search of a better livelihood (*ibid*). However there is a dearth of current migration data in Africa, a continent shaped by migration over a number of centuries. As a result, many statements about African mobility are based more on supposition rather than on empirical evidence. This combination of the lack of empirical data and the use of inappropriate conceptual frameworks has contributed to distorted and highly simplistic views on the nature of African mobility. More empirical research on African mobility is absolutely essential in order to achieve an improved understanding of the subject.

Human land-use and its influence on land cover, is a major factor in the distribution and functioning of ecosystems, and thus in the delivery of ecosystem services (Costanza *et al.*, 1997). Activities such as agriculture, forestry, transport, manufacturing and housing, alter the natural state and ecosystem functions of land, as they involve land-cover conversion or land-use intensification. Thus agricultural intensification affects biodiversity, water resources and soil quality, and contributes to greenhouse gas emissions (EEA, 2006; Ramankutty, 2010). The tropics have the highest biodiversity and tropical forest areas have the largest volume of biomass. However, tropical natural biodiversity, ecosystem functioning and ecosystem services are directly and indirectly threatened by population pressure and a broad variety of human activities, especially land use and mobility, both within and outside of the rural areas (Costanza *et al.*, 1997). It has been estimated that one-fifth of extant vertebrate species are classified as threatened, ranging from 13% of birds to 41% of amphibians (Hoffmann *et al.*, 2010). The per cent increase of Africa's population between 2005 and 2050 of 117 is considered to be the highest compared to other regions during the same length of time (UN, 2007). Studies of land-cover changes in West-Africa show that agricultural expansion is the most dominant trajectory of land-cover change which involves loss of savannah and forest (Wood *et al.,* 2004; Braimoh & Vlek, 2005). Several concepts have been proposed to describe the relationship, functioning and feedback of land-cover (environment), land-use (economy) and socio-cultural conversions (e.g. deforestation) and modifications (e.g. changing land use management such as fertilizer use and irrigation practices) of land-use. These relationships have significance for the functioning of the earth's ecosystems through their impact on biogeochemical cycles (Turner *et al.*, 1994) and important consequences for food security (Brown, 1995).

Cameroon is an agricultural economy and the rural sector, which accounts for 30% of GDP, plays a significant role in her economy (Anonymous, 2008). Despite its importance in the economy of the nation, the rural sector faces many problems that account for declining productivity and biodiversity (Anonymous, 2008) orchestrated by population pressure, mobility and improper land use. From the late 1970s through to 1985 Cameroon was a booming economy. Beginning in 1985 it experienced a devastating economic crisis, a structural adjustment program in 1989 and, in January 1994, a drastic devaluation of its currency (CFA) (Sunderlin & Pokam, 1998). The CFA Franc was devaluated in 1994 by 50% to restore the competitiveness of exports which, coupled with increased world prices for cocoa and coffee, led to a mild resurgence in the profitability of these commodities (Sunderlin & Pokam, 1998). In 1989, the purchase prices of cocoa and coffee (the leading agricultural export earners) were cut in half by the government, greatly adding to the impoverishment of farmers. These economic transformations profoundly influenced population movements and land-use (ibid).

The functioning of any individual farming system is strongly influenced by the external rural environment, policies, institutions, markets and information linkages (Dixon, 2001). Differences in farming systems and land use can alter nutrient input and output fluxes, in soil and vegetation. This can change soil fertility, which in turn affects biomass production and human decisions on land management (Priess, 2001). Nutrient-efficient farming is characterized by the minimization of nutrient losses to the environment while ensuring the necessary nutrient supply to crops and livestock. The tropics and particularly the humid savannah agro-ecological zone in West and Central Africa are generally nutrient-poor ecosystems with potentially low productivity due to erratic rainfall which favour soil degradation. The Western Highlands of Cameroon (WHC) which covers the North-West and West regions however consist of rich volcanic soils coupled with high rural population densities of 48.4 and 59.8 persons per square kilometre respectively. This has contributed to the development of varying patterns of human mobility and land use changes, with major impacts on farming systems, biodiversity and soil nutrient balance in this agro-ecological zone. In this area, farmlands are intensively used due to population pressure. This implies, in spite of higher levels of soil fertility, high inputs of mineral fertilizers and pesticides. In general, production norms for these crops are virtually non-existent and most farmers apply inputs based on their financial capabilities. Due to the shortage of fertile land and water sources for irrigation, human mobility and land-use interactions have reshaped the farming systems, soil nutrient dynamics and biodiversity in the WHC. Agricultural intensification in this zone has led to the switch from 'traditional' to 'modern' farming systems, characterized by the increased use of mineral fertilizers and pesticides. Many farmers in this zone have limited access to inputs but are forced by circumstances to drastically reduce the complexity of their agro-ecosystems in an attempt to intensify production; even though the maintenance of crop diversity is widely accepted as a means of buffering farmers against short-term crop failures (Willey, 1979). The natural biodiversity and the agro biodiversity of the WHC have changed drastically due to forest clearance for agriculture, both in composition and structure, but also more recently due to the replacement of the traditional shifting cultivation with multiple species, by intensive short fallow cultivation systems characterized by sole cropping. The traditionally preserved 'sacred groves' of the area have conserved some of the endemic plant diversity (Khan, 1997),and these sacred groves still have an important function in terms of traditional medicines and the provision of fruits and forest products (Khan, 1997). A major feature of population pressure and consequently human mobility in the WHC is the intensification of land-use for food and feed production. One of the great challenges is to gain a sound scientific understanding of human mobility and land interactions and feedback processes in the complex and highly diverse tropical ecosystems in general, and the humid savannah agro-ecological zone of Cameroon in particular, and its impact on local natural biodiversity and agro biodiversity. Improved knowledge in this field through education must form the basis of any plan to optimize farming systems and land-use planning and halt the accelerating biodiversity loss in the tropics in general and Cameroon in particular, and to improve soil nutrient balance and the sustainability of the farming systems. No studies have been carried out which attempt to understand the relationship between human mobility and land-use interactions in the WHC, considered to be the breadbasket of the Central African sub region, and which has been forced to adjust after severe pressure imposed by socio-politico-economic factors.

1.2 Objectives

The main objective of this study is to determine the interactions between human mobility and farming systems, and the impact on local plant diversity and soil nutrient balance to prevent land degradation and improve sustainability.

- Different land-use practices and abiotic factors.
- Analyse crop and farm-level nutrient balances.

The research questions have been defined as follows:

- What are the forces driving human mobility and their contribution to the development of the different categories of human mobility in the study area?
- What are the levels of sustainability of farming systems and the relationship between sustainability and the different forces driving farming systems in this zone?
- What are the different types of plant diversity of agro-ecosystems and how are they influenced by abiotic factors?
- What impact does the the modification of the farming system have, on soil quality at the crop and farm levels of the study area?

1.3 Conceptual framework

The conceptual framework (Figure 1.1) describes the paradigm linking the elements of the framework. The IPAT identity (Waggoner & Ausubel, 2002) which offers a comprehensive identification of “driving forces” can be used to understand this framework. This relationship presented as population = environmental impact, incorporates both the affluence (A) of the population (P) in question and the technology (T) with which people affect their impact (I). The IPAT equation (I = PAT) inocorporates the combined interaction rather than independent effects in determining environmental change. Farmers in the highly dense WHC have had to adjust to an unsustainable drop in coffee prices on the international market by adopting vegetable cash crop cultivation. The study relies on the hypotheses that the main factors leading to varying household responses, are increasing population and stress imposed by economic factors. The responses to these forces include the expansion of cultivated land and residential areas. Also, the economic hardship that resulted from the drop in market prices of the only cash crop of the study area, coffee, drastically reduced income generation in the rural areas. The production system that reigned when coffee was the main cash crop was long-fallow shifting cultivation or swidden system. Global expansion of cultivated land (conversion) accelerated, along with the intensification of the use of land already cultivated (modification). Neoclassical economics typically accounts for the role of population change through its influence on demand as manifested through the market. When the market signals change, the land-use also changes (Meyer & Turner, 1992).

Swidden cultivation is a natural resource practice strategy that involves the rotation of fields rather than crops and relies on the use of fallow to sustain the production of food crops (Nielsen, 2006). The fallows are cleared by means of slashing and burning, the land is cropped for a short period of time and then left untended while the natural vegetation regenerates. Regardless of a lack of substantiating data, swidden systems have frequently been deemed to be environmentally destructive causing deforestation, soil degradation in terms of erosion and negative nutrient balances and contributing to CO_2 emissions (Brady, 1996; Devendra & Thomas, 2002; Harwood, 1996). This perception is however, increasingly challenged as numerous studies have shown that swidden cultivation in many situations can be a rational economic and environmental choice for resource poor farmers (especially with regard to labour), and that swidden cultivation besides being a production system, provides a range of ecosystem services in terms of hydrology, biodiversity and carbon storage in soil and vegetation (Fox, 2000; Kleinman, 1995, 1996; Nielsen, 2006).

Under the swidden system, there was virtually no demand for off-farm (farm inputs obtained outside the farm such as fertilizers and pesticides bought in the markets and transported to the farm) inputs owing to the natural nutrient regeneration processes and the elimination of pests through long term absence of host plants. Farmers depended on their previous harvests for planting materials which made the system nearly totally dependent on on-farm (farm inputs generated from the farm such as plant nutrients obtained through fallowing and pest control through the elimination of pests during the fallow period) inputs. One of the responses to mitigate this economic crisis was the search for high-income generating cash crops which could be considered as a micro-level factor responsible for mobility (De Jong & Gardner, 1981). Cool season vegetable crops, highly solicited by national and international markets fulfilled the requirements and became the new important cash crops of the WHC.

However, in order to improve livelihoods, another response was the emergence of different types of human mobility. Some household members in WHC migrated to urban centres while some others remained in the rural areas but improved their livelihoods through commuting to favourable cash crop production areas. Hence rural-rural mobility led to a massive occupation of the high altitude zones of the WHC for cool-season crop production and the construction of rural road infrastructure, practical mostly during the dry season and renovated only during periods of political campaigns. Owing to the scarcity of land favourable to these new cash crops, the long fallow production system became technically unfeasible and was replaced to a great extent by intensive land use systems highly dependent on the use of agro-chemicals for the production of the vegetable cash crops. Hence, the interaction between human mobility and farming systems provoked significant modifications, leading to an impact on the farming system, significantly reflected in the change in natural and agro-biodiversity and the soil quality of the zone. In view of the significance of agriculture in the WHC, population dynamics, especially human mobility, could be considered in an ecological context. Agriculture has been the lifeline of the people and for many decades a delicate balance was maintained between the extensive, long-fallow agricultural production system and the fragile environment. But the current prevailing human mobility trends attest to an acute and potentially disastrous imbalance between land-use and natural ecosystems, since rapid population growth increased the demand for land and resulted in intensive land use which eliminated the traditional on-farm dependent system.

1.4 Theoretical framework

One school of thought is the Clifford Geertz's concept of "agricultural involution" (Geertz, 1963) based on the internal complexity within static socio-economic forms in historical Indonesia. Innovative intensification is referred to as increasing the amount of time land is under cultivation in addition to adopting new crops or new techniques, while non-innovative intensification involves increasing cropping intensity while maintaining the same cultivar (Laney, 2002). Non-innovative intensification encompasses increasing inputs without a concurrent techno-managerial shift, which in the extreme leads to a levelling or possibly a decrease in output per unit of input, known as stagnation or involution, respectively (Geertz, 1963). Non-innovative intensification often involves an increase in the crop cover over the course of a given year through a reduction in the length of fallow, while innovative intensification may involve this and/or a shift to a new cultivar, the application of chemical fertilizers and pesticides, the use of petroleum-fuelled machinery, and/or significant alteration in local hydrology. In their analysis of the change in cropping intensities, Keys and McConnell (2005) found that most non-innovative intensification occurred in Africa. African small scale farmers utilize family labour to increase labour input despite decreased marginal productivity. This describes a process of involution and does not clash, in the short-term, with strategies to increase production per capita (Geertz 1963). But if the process continues and more labour is applied on the same parcel of land, the effect will sooner or later be a decreased production per capita and thus an emerging agrarian crisis.

The demographic pressure can have a very severe impact on natural ecosystem services through associated human mobility and changing farming systems. It has become increasingly recognised that a major factor in both commuting and migration is on-going environmental degradation induced by population pressure. Bilsborrow (1979, 1992) suggested a framework that integrated the Malthusian theory that a growing population demographically responded to resource pressure by fertility reduction or out-migration that ultimately reduced resource demands and the Boserupian theory that a population economically responded to resource pressure through changes in agricultural technology that ultimately increased supply. To do this, Bilsborrow (1992) draws on Kingsley Davis's concept of "multiphasic response". Although the response of a growing population could be multiphasic by invo1ving any combination of the demographic, economic and demographic-economic changes considered, Bilsborrow (1992) noted that taking up one response meant the others were less likely to be taken up, because pressure would then be reduced, and the stimulus mollified. According to Von Thunen's classic "concentric zones" model, landscape change is seen as a response to changes in economic land rents associated with increasing transportation costs from the farm to a central market place (Bryant, 1982).

Mukherji Shekhar (2001) proposed a theoretical system perspective approach, and argued that need-attribute systems of the people, utility offerings of the places and different mobility behaviour that arise to satisfy needs, are interdependent parts of a system called the mobility field, and postulated that any natural or induced change in any part of the system would generate corresponding changes in other parts. The need systems of the individuals are regarded as the causal forces acting behind their movement behaviour, and consequently, it is suggested that if it is possible to induce desirable changes in the need-stress attribute structure of the people, then it can effect changes in people's spatial behaviour, and vice-versa. It is also assumed that by inducing change in the spatial arrangement and the utilities of the places, it is possible to induce changes in the behaviour of the people and in their attribute structure. Hence, mobility can be planned to act as an agent of socio-economic change.

Ecosystem services are generated by ecosystem functions which in turn are underpinned by biophysical structures and processes referred to as "supporting services" by the Millennium Ecosystem Assessment (2005). Ecosystem functions are thus intermediate between ecosystem processes and services and can be defined as the "capacity of ecosystems to provide goods and services that satisfy human needs, directly and indirectly" (De Groot, 1992). The dimensions of biodiversity and its relationship to human well-being have been extensively addressed by Levin (2000), including both the services that biodiversity supports and the evolutionary genesis of biodiversity, together with the ecological processes underlying patterns and trends. Ecosystems can be evaluated through the use of indices to measure biodiversity or through the measurement of nutrient flux. Genetic diversity of crops increases production and decreases susceptibility to pests and climate variation (Ewel, 1986; Altieri, 1990; Zhu, 2000). In low-input systems especially, locally adapted varieties often produce higher yields or are more resistant to pests than varieties bred for high performance under optimal conditions (Joshi, 2001).

Influenced by human management, ecosystem processes within agricultural systems can provide services that support the provisioning services, such as pollination, pest control, genetic diversity for future agricultural use, soil retention, regulation of soil fertility and nutrient cycling. The potential of an agricultural system to provide such services depends on the degree of sustainable management (Power, 2010).

Management practices also influence the potential for the impairment or 'disservice' of agriculture, such as loss of habitat for conserving biodiversity, nutrient runoff, sedimentation of waterways, and pesticide poisoning of humans and non-target species (Zhang, 2007). Since agricultural practices can harm biodiversity through multiple pathways, agriculture can be considered as harmful to conservation; however, appropriate management can ameliorate many of the negative impacts of agriculture, while largely maintaining provisioning services (Power, 2010). Agricultural regulating services include, flood control, water quality control, carbon storage and climate regulation through greenhouse gas emissions, disease regulation, and waste treatment (e.g. nutrients, pesticides). Cultural services include scenic beauty, education, recreation and tourism, as well as traditional use. Agricultural places (such as the sacred groves) or products are often used in traditional rituals and customs that bond human communities. Conservation of biodiversity may also be considered a cultural ecosystem service influenced by agriculture, since most cultures recognize the appreciation of nature as an explicit human value. In return, biodiversity can contribute a variety of supporting services to agroecosystems and surrounding ecosystems (Daily, 1997).

Around the world, there are great variations in the structure and function of agricultural ecosystems because they were designed by diverse cultures and under diverse socioeconomic conditions in diverse climatic regions. Functioning agroecosystems include, among others, annual crop monocultures, temperate perennial orchards, grazing systems, arid-land pastoral systems, tropical shifting cultivation systems, smallholder mixed cropping systems, paddy rice systems, tropical plantations (e.g. oil palm, coffee, and cacao), agroforestry systems and species-rich home gardens. This variety of agricultural systems results in a highly variable assortment and quantity of ecosystem services. Just as the provisioning services and products that derive from these agroecosystems vary, the support services, regulating services and cultural services also differ, resulting in extreme variations in the value these services provide, inside and outside the agroecosystem. In maximizing the value of provisioning services, agricultural activities are likely to modify or diminish the ecological services provided by unmanaged terrestrial ecosystems, but appropriate management of key processes may improve the ability of agroecosystems to provide a broad range of ecosystem services (Powel, 2010).

Globally, most landscapes have been modified by agricultural activities and most natural, unmanaged ecosystems are potential agricultural lands. The conversion of undisturbed natural ecosystems to agricultural use can have a strong impact on the system's ability to produce important ecosystem services, but many agricultural systems can also be important sources of services. Indeed, agricultural land use can be considered an intermediate stage in a human impact continuum between wilderness and urban ecosystems (Swinton, 2007). Just as conversion from natural ecosystems to agriculture can reduce the flow of certain ecosystem services, the intensification of agriculture (Matson, 1997) or the conversion of agro ecosystems to urban or suburban development can further degrade the provision ofbeneficial services.

In the WHC, the forces of demographic and economic pressures on the rural population have resulted in a variety of responses.

1.5 Structure of thesis

Chapter 2 deals with the response component of Figure 1.1 and provides case study findings through a structured questionnaire on human mobility in WHC, with an emphasis on the types of human mobility and what changes them, as well as their impact on land-use and occupational diversification in the research site. Chapter 3 constitutes the main impact in Figure 1.1 that examines the impact of the modification of the farming system in the case study locations with a focus on inter-household differences with respect to access of assets, especially farming inputs and their impact on sustainability. In addition, the major factors that influence the farming systems are identified and used to define the sustainability of the research site. The later two chapters examine in detail the main impact component of Figure 1.1. Chapter 4 describes in detail, patterns of agro biodiversity as influenced by types of land use and abiotic factors in the study areas. Chapter 5 focusses on exploring changing trends in soil quality at the crop and farm levels, imposed by the modification of the farming system. The final chapter summarises the key issues related to the main findings of the studies.The factors which driver socio-ecological change included the impact of population pressure on the varying types of human mobility and their effects (Box 1.1).

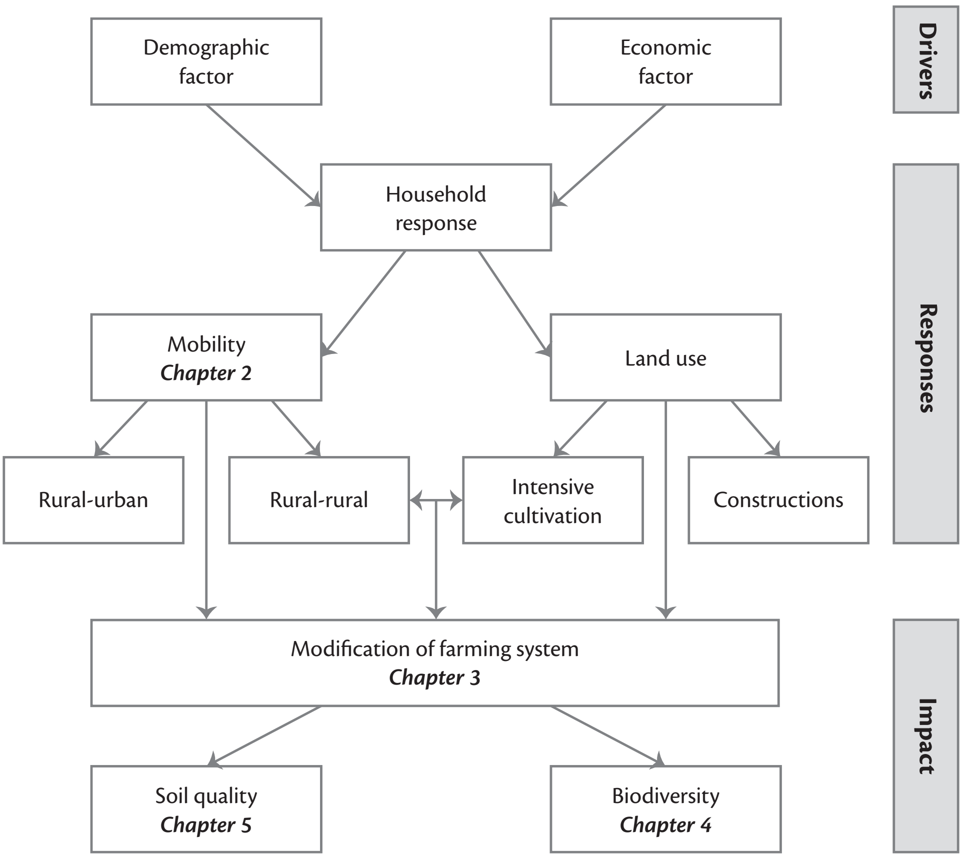

Figure 1.1
Simplified picture of the interaction of mobility and land-use in the WHC.

BOX 1.1

Socio-ecological sustainability

This research seeks to emphasize the environmental perspective with more attention focussed on how human mobility and farming systems address soil health, natural and agro biodiversity and agro-ecological processes that employ closed loop cycles within the farm where possible, to limit inputs and reduce waste. Another obvious component is reducing environmental impacts, enhancing our natural capital and building on environmental services on which our food system depends. Wells (2011) posited that agriculture is an integral nexus of society and ecology over time, a coevolution of culture and nature, humans and landscape. An attempt to broach sustainable agriculture therefore, demands attention to its socio-ecological nature (Wittman, 2009). The social indicators of sustainable agriculture usually underpin social, economic and ecological systems interacting at multiple temporal, spatial and organizational levels (Bacon et al. 2012). The object of this research is an attempt at understanding this, through the analyses of the socio-ecological impacts provoked by demographic pressure and cash crop crisis, in addition to the existing types of human mobility on sustainability indicators in the study area. One of the striking outcomes of urban-rural mobility is the genesis of social or cultural mobility (Chapter 2).

1.6 The study site

The study was conducted in two sub-divisions in the WHC namely Fongo Tongo and Nkong-ni all of which are found in the WHC, one of the major agricultural zones of Cameroon. These two sub-divisions contain all the main features found in the humid savannah zone of Cameroon. The climate of the zone is tropical, with a mono-modal rainfall distribution. The growing season is between mid March and mid November and the dry season is between mid November and mid March. The annual rainfall is between 1000 and 2000mm, annual maximum temperature is 22˚C and annual minimum temperature is 17˚C (Kay, 1985). The soils are ferralitic with high moisture retention capacities (Fotsing, 1992).The altitudinal range of the research sites is between 1400 m and 2000 m and more, above sea level. Cool season vegetable crop production is dominant at higher altitudes. Agricultural activities are also very common in inland valley swamps and steep slopes. The population density is approximated to 59.8 inhabitants per km^2. The natural vegetation is dominated by grass with shrubs and trees. Many households plant their land with eucalyptus trees (most often for border demarcation) commonly using the wood as timber and firewood. Production systems vary with the altitude. At the lower altitudes, intercropping is predominant and crops (both warm and cool season) grown are principally for home consumption while at higher altitudes, sole cropping is more practised and the crops (cool season) grown, are more for the market. Generally people tend to move from the lower altitudes towards the higher altitudes in search of farmland for commercial production and/or labour jobs in commercial farms. Detailed methodologies for the different components of the thesis are elaborated in the various chapters.

References

Adams, M.L., Norvell, W.A., Philpot, W.D. & Peverly, J.H. (2000) Spectral detection of micronutrient deficiency in 'Bragg' soybean. *Agron. J.* 92(2): 261-268.

Adepoju, A.(2001) Population and Sustainable Development in Africa in the 21st century: Challenges and Prospects. HRDC *African Policy Research Series No. 1*. Lagos: Concept Publications.

Adepoju, A. & Hammar, T. (eds.) (1996) *International Migration in and from Africa: Dimension, Challenges and Prospects*. Dakar: PHRDA/Stockholm: CEIFO.

Altieri, M.A. (1990) Agroecology and rural development in Latin America. In: Altieri, M.A. & Hecht, S.B. (eds.) *Agroecology and Small Farm Development*. Florida: CRC Press, pp. 113-118.

Anonymous (1993) Committee on Long Range Soil and Water Conservation (CLSWC). Nitrogen and phosphorus mass balances: methods and interpretation. In: *Soil and water quality: An Agenda for Agriculture*. Washington DC: National Research Council National Academy Press, pp. 431-477.

Anonymous (2001) *The integration of Biodiversity into National Environmental Assessment Procedures*. Biodiversity support progaramme UNDP/UNEF/GEF.

Anonymous (2008) *African Development Bank group. Cameroon evaluation of bank group assistance to the agriculture and rural development sector, 1996-2004*. Operations Evaluation Department (OPEV), 26th February 2008.

Bacon, C. M., Getz, C., Kraus, S., Montenegro, M. & Holland K. (2012) The social dimensions of sustainability and change in diversified farming systems. *Ecology and Society* 17(4): 41.

Balmford, A., Bruner, A., Cooper, P., Costanza, R., Farber, S., Green, R.E., Jenkins, M., Jefferiss, P., Jessamy, V., Madden, J., Munro, K., Myers, N., Naeem, S., Paavola, J., Rayment, M., Rosendo, S., Roughgarden, J., Trumper, K. & Turner, R.K. (2002) Economic reasons for conserving wild nature. *Science* 297(5583): 950-953.

Bell, D. & Taylor, J. (2004) Conclusions: Emerging research themes. In Tayloy, J. & Bell, M. (eds) *Population Mobility and Indigenous peoples in Australasia and North America*. London: Routledge, pp. 262-267.

Bilsborrow, R. (1979) *Population Pressures and Agricultural Development in Developing Countries: A Conceptual Framework and Recent Evidence*. Paper presented at Population Association of America (PAA) Annual Meeting.

Bilsborrow, R. (1992) Population growth, internalmigration, and environmental degradation in rural areas of developing countries. *European Journal of Population* 8: 125-148.

Binns, J.A., Maconachie, R.A. & Tank, A.I. (2003) Water, land and health in urban and peri-urban food production: the case of Kano, Nigeria. *Land Degradation and Development* 14: 431-444.

Black, R., Kniveton D., Skeldon R., Coppard D., Murata A. & Schmidt-Verkerk K. (2008) *Demographics and Climate Change: Future Trends and their Policy Implications for Migration*, Working Paper T-27, Development Research Centre on Migration, Globalisation and Poverty.

Bosch, H. van den, Vlaming, J., Wijk, M.S. van, Jager, A. de, Bannink, A. & Keulen, H. van (2001) *Manual to the NUTMON methodology*. Wageningen, the Netherlands: Alterra/LEI, Wageningen University and Research centre.

Brady, N.C. (1996) Alternatives to Slash-and-Burn: A Global Imperative. *Agriculture, Ecosystems & Environment* 58: 3-11.

Braimoh, A. & Vlek, P. (2005) Land-cover change trajectories in northern Ghana. *Environmental Management* 36(3): 356-373.

Briassoulis, H. (2000) *Analysis of Land Use Change: Theoretical and Modelling Approaches*. The webbook of regional science (www.rri.wvu.edu/regscweb.htm). Regional Research Institute, West Virginia University.

Bray, J.R. (1960) The chlorophyll content of some native and managed plant communities in central Minnesota. *Can. J. Bot.* 38: 313-333.

Bray, J.R. (1961) An estimation of a minimum quantum yield of photosynthesis based on ecological data. *Pl. Physiol* 36: 371-373.

Brougham, R.W. (1960) The relationship between the critical leaf area, total chlorophyll content, and maximum growth rate of some pasture crops. *Ann. Bot. (N.S.)* 24: 463-474.

Brown, L.R. (1995) *Who will feed china? Wake-Up call for a small planet*. New York: The World Watch Environmental Alert Series.

Bryant, C.R., Russwurm, L.H. & McLellan, A.G. (1982) *The City's Countryside: Land and its Management in the Rural-Urban Fringe*. London and New York: Longman.

Costanza, R., d'Arge, R., Groot, R. de, Farber, S., Grasso, M., Hannon, B., Naeem, S., Limburg, K., Paruelo, J., O'Neill, R.V., Raskin, R., Sutton, P., & Belt, V. van den (1997) The value of the world's ecosystem services and natural capital. *Nature* 387: 253-260.

Daily, G.C. (eds) (1997) *Nature's services: societal dependence on natural ecosystems*. Washington, DC: Island Press.

Das, K.K., Ravan, S.A., Negi, S.K., Jain, A. & Roy, P.S. (1996) Forest cover monitoring using Remote Sensing and GIS – A case study in Dhaulkhand range of Rajaji National Park, Uttar Pradesh. Photonirvachak. *Jour. Ind. Soc. Remote Sensing* 24(1): 33-42.

Devendra, C., & Thomas, D. (2002) Smallholder Farming Systems in Asia. *Agricultural Systems* 71: 17-25.

De Bruijn, M. & Dijk, H. van (2003) Changing population mobility in West Africa: Fulbe pastoralists in Central and South Mali. *African Affairs* 102: 285-307.

De Groot, R.S. (1992) *Functions of Nature, Evaluation of Nature in Environmental Planning, Management and Decision Making*. Wolters-Noordhoff, Groningen, the Netherlands.

De Haas, H. (1998) Socio-Economic Transformations and Oasis Agriculture in Southern Morocco. In: Haan, L. de & Blaikie, P. (eds) *Looking at Maps in the Dark. Directions for Geographical Research in Land Management and Sustainable Development in Rural and Urban Environments of the Third World*. Netherlands Geographical Studies 240, pp. 65-78. Utrecht/Amsterdam: KNAG/FRW, UvA.

De Haas, H. (2009) *Mobility and Human Development.United Nations Development Programme*. Human Development Research paper 2009/01.

De Jong, G.F. & Gardner, R.W. (1981) Migration Decision Making: Multidisciplinary Approaches to Microlevel Studies in Developed and Developing Countries. In: Jong, G.F. de & Gardner, R.W. (eds) *Studies in Developed and Developing Countries*. New York: Pergamon Press.

Dixon, J., Gulliver, A., Gibbon, D., & Hall, M. (2001) F*arming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World.* FAO.

Earl, H.J. & Davis, R.F. (2003) Effect of drought stress on leaf and whole canopy radiation use efficiency and yield of maize. *Agron. J.* 95: 688–696.

Earl, H.J. & Tollenaar, M. (1998) Relationship between thylakoidelectron transport and photosynthetic CO_2 uptake in leaves of three maize (Zea mays L.) hybrids. *Photosynth. Res.* 58: 245-257.

EEA (2006) *How much bioenergy can Europe produce without harming the environment?* EEA Report No 7/2006. European Environment Agency.

Ewel, J. (1986) Designing agricultural systems for the humid tropics. *Annual Review of Ecology and Systematics* 17: 245-271.

Fotsing, J.M. (1992) Stratégies paysannes de gestion de terrains et de LAE en pays Bamiléké Ouest Cameroun. *Bull. Réseau Erosion* 12: 241-254.

Fox, J. (2000) How Blaming 'Slash and Burn' Farmers is Deforesting Mainland Southeast Asia. *Asia Pacific Issues* 47: 1-8.

Garty, J., Tamir, O., Hasid, I. Eschel, A., Cohen, Y., Kamieli, A. & Orlovsky, L. (2001) Photosynthesis, chlorophyll integrity, and spectral reflectance in lichens exposed to air pollution. *J. Environ. Qual.* 30: 884-893.

Geertz, C. (1963) A*gricultural Involution.The Processes of Ecological Change in Indonesia*. University of California Press Berkeley.

Geist, H.J. & Lambin, E.F. (2001) *What drives deforestation? A meta-analysis of proximate and underlyingcauses of deforestation based on subnatinal case study evidence*. LUCC Report Series 4, pp. 116.

Ghosh, S., Sen, K.K., Rana, U., Rao, K.S. & Saxena, K.G. (1996) Application of GIS for Land-Use/Land- Cover change analysis in a Mountainous Terrain, Photonirvachak. *Jour. Ind. Soc. Remote Sensing* 24(3): 193-202.

Goldring, L. (2004) Family and collective remittances to Mexico: A multi-dimensional typology. *Development and Change* 35: 799-840.

Harwood, R.R. (1996) Development Pathways Toward Sustainable Systems Following Slash-and-Burn. *Agriculture, Ecosystems and Environment* 58: 75-86.

Henry, S., Schoumaker, B. & Beauchemin, C. (2004) The Impact of Rainfall on the First Out-Migration: A Multi-level Event-History Analysis in Burkina Fas., *Population and Environment* 25(5): 423-460.

Hoffmann, M., Hilton-Taylor, C., Angulo, A., Böhm, M., Brooks, T.M., Butchart, S.H., Carpenter, K.E., Chanson, J., Collen, B., Cox, N.A., Darwall, W.R., Dulvy, N.K., Harrison, L.R., Katariya, V., Pollock, C.M., Quader, S., Richman, N.I., Rodrigues, A.S., Tognelli, M.F., Vié, J.C., Aguiar, J.M., Allen, D.J., Allen, G.R., Amori, G., Ananjeva, N.B., Andreone, F., Andrew, P., Aquino, Ortiz, A.L., Baillie, J.E., Baldi, R., Bell, B.D., Biju, S.D., Bird, J.P., Black-Decima, P., Blanc, J.J., Bolaños, F., Bolivar, G.W., Burfield, I.J., Burton, J.A., Capper, D.R., Castro, F., Catullo, G., Cavanagh, R.D., Channing, A., Chao, N.L., Chenery, A.M., Chiozza, F., Clausnitzer, V., Collar, N.J., Collett, L.C., Collette, B.B., Cortez, Fernandez, C.F., Craig, M.T., Crosby, M.J., Cumberlidge, N., Cuttelod, A., Derocher, A.E., Diesmos, A.C., Donaldson, J.S., Duckworth, J.W., Dutson, G., Dutta, S.K., Emslie, R.H., Farjon, A., Fowler, S., Freyhof, J., Garshelis, D.L., Gerlach, J., Gower, D.J., Grant, T.D., Hammerson, G.A., Harris, R.B., Heaney, L.R., Hedges, S.B., Hero, J.M., Hughes, B., Hussain, S.A., Icochea, M.J., Inger, R.F., Ishii, N., Iskandar, D.T., Jenkins, R.K., Kaneko, Y., Kottelat, M., Kuzmin, S.L., La Marca, E., Lamoreux, J.F., Lau, M.W., Lavilla, E.O., Leus, K., Lewison, R.L., Lichtenstein, G., Livingstone, S.R., Lukoschek, V., Mallon, D.P., McGowan, P.J., McIvor, A., Moehlman, P.D., Molur, S., Muñoz, Alonso, A., Musick, J.A., Nowell, K., Nussbaum, R.A., Olech, W., Orlov, N.L., Papenfuss, T.J., Parra-Olea, G., Perrin, W.F., Polidoro, B.A., Pourkazemi, M., Racey, P.A., Ragle, J.S., Ram, M., Rathbun, G., Reynolds, R.P., Rhodin, A.G., Richards, S.J., Rodríguez, L.O., Ron, S.R., Rondinini, C., Rylands, A.B., Sadovy de Mitcheson, Y., Sanciangco, J.C., Sanders, K.L., Santos-Barrera, G., Schipper, J., Self-Sullivan, C., Shi, Y., Shoemaker, A., Short, F.T., Sillero-Zubiri, C., Silvano, D.L., Smith, K.G., Smith, A.T., Snoeks, J., Stattersfield, A.J., Symes, A.J., Taber, A.B., Talukdar, B.K., Temple, H.J., Timmins, R., Tobias, J.A., Tsytsulina, K., Tweddle, D., Ubeda, C., Valenti, S.V., Dijk, P.P. van, Veiga, L.M., Veloso, A., Wege, D.C., Wilkinson, M., Williamson, E.A., Xie, F., Young, B.E., Akçakaya, H.R., Bennun, L., Blackburn, T.M., Boitani, L., Dublin, H.T., da Fonseca, G.A., Gascon, C., Lacher, T.E. Jr, Mace, G.M., Mainka, S.A., McNeely, J.A., Mittermeier, R.A., Reid, G.M., Rodriguez, J.P., Rosenberg, A.A., Samways, M.J., Smart, J., Stein, B.A. & Stuart, S.N. (2010). The Impact of Conservation on the Status of the World's Vertebrates. *Science* 330(6010): 1503-1509.

Jiang, Y., & Huang, B. (2000) Effects of drought or heat stress alone and in combination on Kentucky bluegrass. *Crop Sci.* 40: 1358-1362.

Joshi, J., Schmid, B., Caldeira, M.C., Dimitrakopoulos, P.G., Good, J., Harris, R., Hector, A., Huss-Danell, K., Jumpponen, A., Minns, A., Mulder, C.P.H., Pereira, J.S., Prinz, A., Scherer-Lorenzen, M., Siamantziouras, A.-S.D., Terry, A.C., Troumbis, A.Y. & Lawton, J.H. (2001) Local adaptation enhances performance of common plant species. *Ecology Letters* 4(6): 536-544.

Kay, M., Stephens, W. & Carr, M.K.V. (1985) Prospects for small-scale irrigation in sub-Saharan Africa. *Outlook on agriculture* 14(3): 115-121.

Kelly, R.L. (1992) Mobility/Sedentism.Concepts: Archaelogical Measures and Effects. *Annual Review of Anthropology* 21: 43-66. In: Taylor, J. & Bell, M. (eds) *Population Mobility and Indigenous peoples in Australasia and North America*. London: Routledge, pp. 117-135.

Keys, E. & McConnell, W.J. (2005) Global change and the intensification of agriculture in the tropics. *Global Environmental Change-Human and Policy Dimensions* 15: 320-337.

Khan, M.L., Menon S. & Bawa K.S. (1997) Effectiveness of the protected area network in biodiversity conservation: a case study of Meghalaya state. *Biodiv. Conserv.* 6: 853-868.

Kleinman, P.J.A., Pimentel, D. & Bryant, R.B. (1995) The Ecological Sustainability of Slash-and-Burn Agriculture. Agriculture, *Ecosystems & Environment* 52: 235-249.

Kleinman, P.J.A., Bryant, R.B. & Pimentel, D. (1996) Assessing Ecological Sustainability of Slash-and-Burn Agriculture through Soil Fertility Indicators. *Agronomy Journal* 88: 122-127.

Lacroix, T. (2005) *Les réseaux marocains du développement: Géographie dutransnational et politiques du territorial*. Paris: Presses de Sciences Po.

Lambin, E., Geist, H. & Lepers, E. (2003) Dynamics of land-use and land-cover change in tropical regions. *Annual Review of Environment and Resources* 28: 205-241.

Levin, S.A. (ed.) (2000) *Encyclopedia of Biodiversity*, Five-Volume Set, 2nd edition. Academic Press. 4666 pp.

Lewis, J.R. (1986) International Labour Migration and Uneven Regional Development in Labour Exporting Countries. *Tijdschrift voor Economische en Sociale Geografie* 77: 27-41.

Lipton, M. (1980) Migration from the rural areas of poor countries: The impact on rural productivity and income distribution. *World Development* 8: 1-24.

Loreau, M. (2000) Biodiversity and ecosystem functioning: recent theoretical advances. *Oikos* 91: 3-17.

May, R.M. (1973) *Stability and Complexity in Model Ecosystems*. Princeton University Press.

Millennium Ecosystem Assessment (MA) (2005) *Ecosystems and Human Well-Being: Current State and Trends*. Washington, DC: Island Press.

Matson, P.A., Parton, W.J., Power, A.G. & Swift, M.J. (1997) Agricultural intensification and ecosystem properties. *Science* 277: 504-509.

Meisinger, J.J. & Randall, G.W. (1991) Estimating Nitrogen budgets for soil-crop systems. In: Follett, R.F., Keeney, D.R. & Cruse, R.M. (eds) *Managing nitrogen for groundwater quality and farm profitability*. Wisconsin: SSSA Madison, pp. 85-124.

Meyer, W.B. & Turner II, B.L. (1992) Human Population, Growthand Global Land-use/cover Change. *Annu. Rev. Ecol. Syst.* 23: 39-61.

Mukherji, S. (2001) *International Mobility Field Theory: Extension of The Mobility Field Theory for Linking Internal and International Migration*. 24th IUSSP Conference, Salvador, Brazil.

Munters, P.J.A.L. (1997) *The Dutch Manure Policy: MINAS (Nutrient accounting system)*. Report from Dutch Dept. of Agriculture of the Ministry of Agriculture, Nature Management and Fisheries.

Newbold, B. (2004) Data sources and Issues for the Analysis of Indigenous People's Mobility. In: Oglethorpe J., Ericson J., Bilsborrow R.E. & Edmond J. (2007) *People on the Move: Reducing the Impacts of Human Migration on Biodiversity*. Washington, D.C.: World Wildlife Fund and Conservation International Foundation.

Nielsen, U., Mertz, O. & Noweg, G.T. (2006) The Rationality of Shifting Cultivation Systems: Labor Productivity Revisited. *Human Ecology* 34: 210-218.

Parnwell, M. (1993) *Population Movements in the Third World*. London: Routledge.

Piguet, E. (2008) *Climate Change and Forced Migration*, Research Paper no. 153. Geneva: UNHCR.

Pike, J.G. (1968) *Malawi: A Political and Economic History*. London, Pall Mall Press.

Pike, J.G. & Rimmington, G.T. (1965) *Malawi. A geographical study*. London: O.U.P., 229 p.

Powel, A.G. (2010) Ecosystem services and agriculture: tradeoffs and synergies. *Phil. Trans. R. Soc. B*. 365: 2959-2971.

Priess, J.A., Koning, G.H.J. de & Veldkamp A. (2001) Assessment of interactions between land use change and carbon and nutrient fluxes in Ecuador. *Agric Ecosyst Environ* 85: 269-279.

Quinn, Michael A. (2006) Relative Deprivation, Wage Differentials and Mexican Migration. *Review of Development Economics* 10: 135-153.

Ramankutty, N. (2010) Agriculture and forests – recent trends, future prospects. In: *Linkages of sustainability*. MIT Press, pp. 11-31.

Ratha, D. & Shaw, W. (2007) *South-South Migration and Remittances*, Washington D.C.: The World Bank Working Paper no. 102.

Reid, W.V. (1992) Tropical Deforestation and Species Extinction. In: Whitmore, T.C. & Sayer, J.A. (eds) How Many Species Will There Be? London: Chapman & Hall, pp. 55-73.

Rubenstein, H. (1992) Migration. Development and Remittances in Rural Mexico. *International Migration* 30.

Ryan, P.A. (1999) *The use of revegetated areas by vertebrate fauna in Australia: a review*. Shepparton, Victoria, Australia: GBCMA.

SID (Society for International Development) (2002) *Declaration of The Hague on the Future of Refugee and Migration Policy*. The Hague: SID Netherlands Chapter.

Simmel, G. (1990) *The Philosophy of Money*, 2nd ed., trans. Bottomore, T. & Frisby, D. London: Routledge.

Sørensen, T.A. (1948) A method of establishing groups of equal amplitude in plant sociology based on similarity of species content, and its application to analyses of vegetation of Danish commons. *Biol. Skr., Kongl. Danske Videnske. Selsk* 5: 1-34.

Stark, O. & Taylor, J.E. (1989) Relative Deprivation and International Migration. *Demography* 26(1): 1-14.

Sunderlin, W. & Pokam, J. (1998) *Economic crisis and forest cover change in Cameroon: the roles of migration, crop diversification, and gender division of labor*. Unpublished manuscript. Bogor: Center for International Forestry Research, .

Swindell, K. (1984) Farmers, traders and labourers: dry season migration from North-West Nigeria. *Africa* 54: 3-18.

Swindell, K. & Iliya, M.A. (1999) Making a profit, making a living: commercial food farming and urban hinterlands in North-West Nigeria. *Africa* 69: 386.

Swinton, S.M., Lupi, F., Robertson, G.P. & Hamilton, S.K. (2007) Ecosystem services and agriculture: cultivating agricultural ecosystems for diverse benefits. *Ecol. Econ.* 64: 245-252.

Tacoli, C. (2002) *Changing rural-urban interactions in sub-Saharan Africa and their impact on livelihoods.* Working Paper Series on Rural-Urban Interactions and Livelihood Strategies. London: International Institute for Environment and Development (IIED).

Taylor, E. (1984) Egyptian migration and peasant wives. *Merip reports* 124: 3-10.

Tilman, D. (1996) Biodiversity: population versus ecosystem stability. *Ecology* 77: 350-363.

Tilman, D., Lehman, C. & Thomson, K.T. (1997) Plant diversity and ecosystem productivity: theoretic al considerations. *Proc. Natl Acad. Sci. USA* 94: 1857-1861.

Tilman, D., Reich, P.B., Knops, J., Wedin, D., Mielke, T. & Lehman, C. (2001) Diversity and productivity in a longterm grassland experiment. *Science* 294: 843-845.

Tilman, D., Cassman, K.G., Matson, P.A., Naylor, M. & Polasky, S. (2002) Agricultural sustainability and intensive production practices. *Nature* 418: 671-677.

Trung, N.H., Tri, L.Q., Van Mensvoort, M.E.F. & Bregt, A. (2006) Comparing Land-Use Planning Approaches in the Coastal Mekong Delta of Vietnam. In: Hoanh, C. T., (eds) *Environment and Livelihoods in Tropical Coastal Zones: Managing Agriculture-Fishery-Aquaculture Conflicts.* UK: CABI Publishing.

Turner II, B.L., Moss, R.H. & Skole, D.L. (1993) *Relating Land Use and Global Land-Cover Land Change*. IGBP Report No. 34 and HDP Report No. 5. Stockholm: IGBP/HDP.

Turner II, B.L., Skole, D., Sanderson, S., Fischer, G., Fresco, L. & Leemans, R. (1995) *Land-Use and Land-Cover Change; Science/Research Plan*. IGBP Report no. 35; HDP Report No. 7.

United Nations University – Institute for Environment and Human Security (2005) *As Ranks of 'Environmental Refugees' Swell Worldwide, Calls Grow for Better Definition*, Recognition, support, UN Day for Disaster Reduction, 12th October [www.ehs.unu.edu/file.php?id=58].

Van den Bosch, H., De Jaeger, A. & Vlaming, J. (1998) Monitoring nutrient flows and economic performance in African farming systems (NUTMON). II. Tool development. *Agriculture, Ecosystems and Environment* 71: 49-62.

Van der Hoek, W., Ul Hassan, M., Ensink, J.H.J., Feenstra, S., Raschid-Sally, L., Munir, S., Aslam, R., Ali, N., Hussain, R. & Matsuno, Y. (2002) *Urban wastewater: a valuable resource for griculture. A case study from Haroonabad, Pakistan*. Research Report 63. Colombo: International Water Management Institute (IWMI).

Waggoner, P.E. & Ausubel, J.H. (2002) A framework for sustainability science: a renovated IPAT identity. *Proceedings of the National Academy of Sciences* 99(12): 7860-7865.

Watson, C.A. & Stockdale E.A. (1997) Using nutrient budgets to evaluate the sustainability of farming systems. *Newsletter of the European Network on Organic Farming* 5: 16-19.

Ying, J., E.A., L. & Tollenaar, M. (2002) Response of leaf photosynthesis during the grain-filling period of maize to duration of cold exposure, acclimation, and incident PPFD. *Crop Sci.* 42: 1164-1172.

Young, A. (1990) Agroforestry for the management of soil organic matter. In: *Organic-matter Management and Tillage in Humid and subhumid Africa*. IBSRAM Proceedings 10. Bangkok: IBSRAM, pp. 285-303.

Wells, S. (2011) *Pandora's seed: the unforeseen cost of civilization*. New York, USA: Random Hous.

Willey, R.W. (1979) Intercropping – Its importance and research needs. Part. I: Competition and Yield advantages. *Field Crops Abstr.* 32: 1-10.

Wittman, H. (2009) Reworking the metabolic rift: La Vía Campesina, agrarian citizenship, and food sovereignty. *Journal of Peasant Studies* 36(4): 805-826.

Wood, E.C., Tappan, G.G. & Hadj, A. (2004) Understanding the drivers of agricultural land use change in south-central Senegal. *Journal of Arid Environments* 59(3): 565-582.

World Resources Institute (2005) *Millennium Ecosystem Assessment*, Washington, D.C.: IslandPress.

Zhang, W., Ricketts, T.H., Kremen, C., Carney, K. & Swinton, S.M. (2007) Ecosystem services and dis-services to agriculture. *Ecol. Econ.* 64: 253-260.

Zhu, Y.Y., Chen, H., Fan, J., Wang, Y.,Li, Y., Chen, J., Fan, J.X., Yang, S., Hu, L., Leung, H., Mew, T.W., Teng, P.S., Wang, Z. & Mundt, C.C. (2000) Genetic diversity and disease control in rice. *Nature* 406: 718-722.