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The Role of Agriculture in a Changing World

Vulnerability and Sustainability of Rural Poor Households in Makrugbeh, Northern Sierra Leone

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Table of contents

List of abbreviations and acronyms

CCAFS	Climate Change, Agriculture and Food Security
CEC	Cationic-Exchange-Capacity
CGIAR	Consultative Group on International Agricultural Research
COP	Conference of the Parties
CO_2	Carbon Dioxide
CO_2^{eq}	Carbon Dioxide equivalents
DFID	Department for International Development
FAO	Food and Agriculture Organization
GHG	Greenhouse Gas
GHI	Global Hunger Index
GoSL	Government of Sierra Leone
HDI	Human Development Index
HDR	Human Development Report
IFPRI	International Food Policy Research Institute
IFOAM	International Federation of Organic Agriculture Movements
IIED	International Institute for Environment and Development
IPCC	International Panel on Climate Change
LEISA	Low External Input Sustainable Agriculture
LULUCF	Land Use, Land Use Change and Forestry
MAFFS	Ministry of Agriculture, Forestry and Food Security
MDG	Millennium Development Goal
MLCPE	Ministry of Lands, Housing, Country Planning and the Environment
NAPA	National Adaptation Plan for Action
PAR	Pressure and Release model
PRA	Participatory Rural Appraisal
REDD	Reducing Emissions from Deforestation and Degradation
RISE	Response-Inducing Sustainability Evaluation
SHL	*Schweizerische Hochschule für Landwirtschaft* (Swiss College for Agriculture)
SLA	Sustainable Livelihoods Approach
SLARI	Sierra Leone Agricultural Research Institute
SOM	Soil Organic Matter

SSA	Sub-Saharan Africa
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Fund for Population Activities
UNISDR	United Nations International Strategy for Disaster Reduction
VASA	Vulnerability and Sustainability Assessment
WCED	World Commission on Environment and Development
WGBU	*Wissenschaftlicher Beirat Globale Umweltveränderungen* (German Advisory Council on Global Change)

List of figures

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Abstract

This thesis is giving insight to the complex human-environmental linkages of global change. In order not to exceed the earth's carrying capacity, a paradigm shift towards global sustainable development is inevitable. One key element of global change is land and the way how it is being used. Most important way of land-use is arable farming, mainly for food production. Agriculture stands in reciprocal relation with climate change: On the one hand, agricultural performance and hence food security is highly dependent on climatic conditions. On the other hand, the sectors agriculture and forestry are contributing with roughly 30 percent to the global greenhouse effect.

Rural poor households highly depend on agricultural production to sustain their livelihoods. They make up one of the most vulnerable groups with regard to climate change and food insecurity. Vulnerability in this context is defined as combination of baseline vulnerability, risk exposure and coping and adaptation capacity. The sustainability of a farming system highly correlates with its vulnerability to climate change and food insecurity. Thus, locally adapted sustainable agriculture is the key for reducing these vulnerabilities.

In Makrugbeh, a small village in Northern Sierra Leone, a set of different methods of rural appraisal was conducted in order to give insight in the status and linkages of vulnerability and sustainability on farm-level. For the analysis, an integrated research framework was implemented in the field: The Vulnerability and Sustainability Assessment (VASA) includes a standardized questionnaire, different methods of Participatory Rural Appraisal and the sustainability analysis RISE (Response-Inducing Sustainability Evaluation). The empirical findings are cross-checked with information from secondary sources.

The results show a critical picture: The baseline vulnerability in the village is low, especially with regard to food security; Climate change is already affecting farming activities and is predicted to have further impact on the region; Low coping and adaptation capacities increase the vulnerability of the farming households. This is partly related to the critical status of sustainability on farm-level. There is a variety of potential measures on farm-level and on broader scale for decreasing the vulnerability to climate change and food insecurity and enhancing the sustainability of the households.

1. Introduction

On October 31st 2011 a baby, born in the hospital of Manila on the Philippines, was named the symbolic seven-billionth person on the world. The denomination of the exact one newborn breaking through the seven billion people line is of course not possible, nevertheless, this news has more than just symbolic character[1]. It stands for a world that is changing permanently and obviously faster than ever before.

The issues discussed with regard to our constantly growing world population are not brand-new: How shall we feed so many people if millions are already suffering from hunger? How does our growing population influence the climate and natural eco-systems? Are the natural resources sufficient for so many people and for our present lifestyles? What can we do to sustain our natural environment, as well as to combat hunger and extreme poverty?

Everything is interrelated. The world is a complex system of human-environmental linkages and interdependencies. Several factors within this intertwined global system are in process. The exponential growing population is one of them. Other processes of global change can be repeatedly found in everyday's news: The global financial crisis, food price increases, migration flows in the Mediterranean, or - presently most prominent - climate change.

The occurrence of most of these developments is not new, but new or rather different is the intensity with which all these processes are confronting us presently. Furthermore, interdependencies expand in spatial scale as well as in their thematic dimension: Global change takes place. A German student is related to an Indonesian textile worker, as soon as (s)he is buying clothes, produced in the respective Indonesian factory. And a pastoral farmer in Mali is influenced by Canadian political decisions, if these do not stem massively the deforestation of huge areas of primary forest in their country. Such relations do not reflect direct causalities and they are for sure not one-dimensional. But they do exist.

The availability of information on global change is increasing, as well as public awareness of it. The enormous mass and speed of parallel changing developments additionally draw medial and public attention to globalization and global change.

The complex system of human-environmental linkages makes it difficult to identify clear causal structures. The final impacts on human and natural livelihoods and its

[1] The UN is launching an information campaign to raise awareness on the challenges and opportunities of a world with a population of seven billion people, see <www.7billionactions.org> for more information.

consequences are not always predictable, but research is being done in different scientific disciplines and regional scopes to broaden our understanding and analytic capabilities of global change.

Focussing in more detail on the initial questions of the relation between population growth, human activities and food security, several conclusions can be drawn. The way and quantity how we humans are using the natural resources is already exceeding the earth's carrying capacity. Although, some regions do not (yet) experience the consequences, channelled for example through climate change, others already suffer from global warming and its impacts on human livelihoods. The vulnerabilities to climate change impacts differ, dependent on local structures, risk exposure and coping capacities. In general, more and more people are suffering from poverty, hunger and food insecurity every day. The reasons for food insecurity are manifold and dependent on the specific local context. Nevertheless, global common structural causes can be identified worldwide.

There is general consensus, that sustainable development is inevitable to combat or at least to cushion the negative consequences of global change processes. Several attempts to provide a global platform for sustainable present and future development have been initiated. Additionally, new threats and challenges for human livelihoods are coming up next to the aggravation of already existing problems. More and more, general global approaches seem to be unable to cover the variety of livelihood challenges and local contexts that are affected by global change in completely differing way and severity. Regionally adapted and thematic specific approaches needs to be taken into account for sustainable development in times of global change.

Land and land-use patterns are key elements in the system of global change, as they are intertwined in human-environmental linkages: Global environmental changes, influenced partly by human activity, lead to soil and land degradation and influence basic agricultural conditions. Furthermore, the way of using (arable) land has reverse effect on natural eco-systems and their functions. Based on its location and perception, land plays a focal role in human livelihoods. Products of arable land-use provide basic assets: food, fodder for livestock, fuel (firewood, biofuels) and fibres for construction works and others.

In recent decades, climate change gained more and more attention in academic circles as well as in public media. Several causes of natural and anthropogenic influence on rising concentration of greenhouse gases (GHG) in the atmosphere have been identified and

more and more studies of vulnerability and impact assessments are being published. The International Panel on Climate Change (IPCC), a circle of experts from all around the world published its fourth assessment report in 2007, giving insight in recent research on causal structures of climate change and sectoral as well as regional vulnerability and impact analysis.

The linkage between climate change and agriculture is reciprocal: On the one hand, agricultural performance and yield is highly dependent on climatic conditions. Changes in precipitation patterns or solar radiation affect soil amendments and crop developments. On the other hand, roughly one third of human induced GHG emissions come from agricultural activities. Main sources are cattle breeding, wet-rice farming and the increasing use of chemical fertilizers. Certain land-use changes that release CO_2 or equivalent GHGes in the atmosphere have further impact, for example deforestation and drying up of wetlands and peat.

Hence, the agricultural sector is in need of adaptation to climate change, but it contains as well potential of contributing to its mitigation. The respective measures of adaptation or mitigation depend on local specific conditions and can sometimes even synergize.

Sustainable farming is increasingly discussed with regard to its potential for climate change adaptation and mitigation. Several studies indicate advantages of organic farming methods compared to conventional agriculture. In general, sustainable agriculture has the potential to provide adopted adaptation features as well as synergetic mitigation measures for rural households. Furthermore, organic farming can increase food security on local scale, if adapted to the specific ecological and socio-economic conditions.

Rural poor households are especially vulnerable to climate change and other stress, such as food insecurity due to low development status and poverty. Their vulnerability is based on the underlying baseline vulnerability of the farming system, the exposure to certain risks and the system-inherent coping and adaptation capacity. The more sustainable the farming household, the lower is its vulnerability.

With this thesis, the complex system of global change is discussed on broad scale and later specified in spatial and thematic dimension. The focus of interest lies on the interdependencies between climate change, agriculture and food security. By analysing the vulnerability and sustainability situation on farm level in Makrugbeh, Northern Sierra Leone, the general perceptions are deduced to a specific case study. The analysis is based on the combination of two different perspectives: The spatial and the thematic

dimension. The sand-clock shaped structure of the work is visualized in figure 1: First, the issue of global change is discussed on broad scale. Later, the focus is drawn in both dimensions: On the one hand, the spatial perspective is drawn on the group of developing countries and finally on the ones located in the humid tropics. With regard to the thematic dimension, the specific of role land and land-use is discussed in general and with its linkages to climate change and food security. Finally, the case study is presented with specific spatial and thematic focus: The analysis of vulnerability to climate change and food insecurity and sustainability of rural poor households in Makrugbeh. After discussing the results, the findings are expanded back on broader spatial and thematic level: The potentials of sustainable agriculture in the region of the humid tropics are presented as well as the concept of sustainability as cross-sector approach.

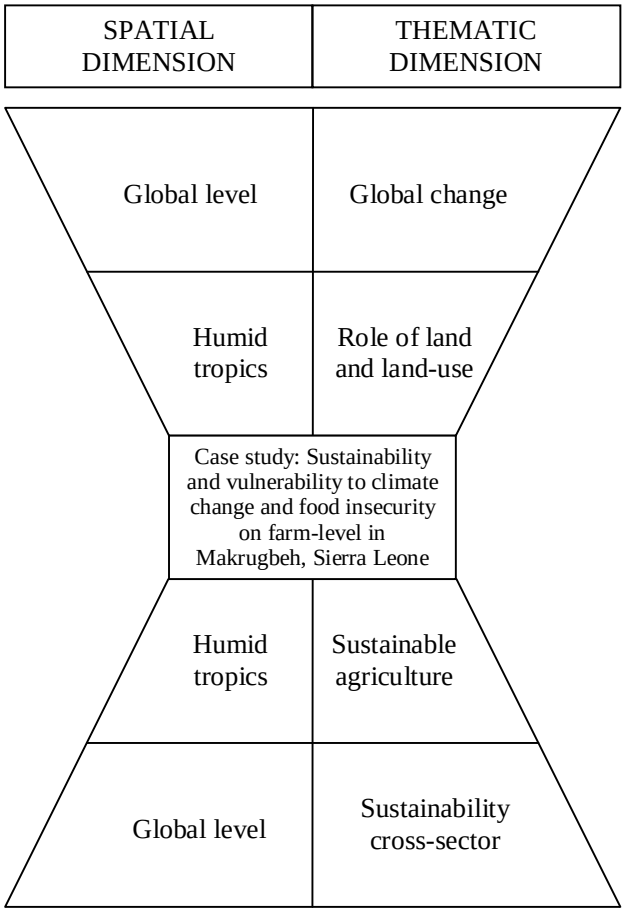

Figure 1: Overview of the two dimensions of global change analysis in this thesis.

This thesis is structured into five main sections: In chapter two, the complex system of global change is introduced, based on the differentiation between its three components: Global environmental change, globalization and global mankind change. With regard to

the challenges of global change and the *limits on growth*, the need for sustainable development is explained. Finally, the focus is drawn on the crucial role of land and sustainable land-use, especially with regard to climate change and food security.

Chapter three provides insight to basic theories and models of vulnerability assessment. The categories of social vulnerability research on the one hand and more natural-science based risk-hazard studies on the other hand, are presented. With regard to global change research, the need of an integrated approach is discussed. Finally, the research framework for Vulnerability and Sustainability Assessment (VASA) on farm-level is introduced: The vulnerability of rural poor households consists of the categories: (1) Baseline vulnerability, (2) risk exposure and (3) coping and adaptation capacity. The degree of sustainability on farm-level is correlating with its baseline vulnerability and coping and adaptation capacity.

In chapter four, this framework is integrated in the specific research design for the case study analysis. The methods conducted in the field are presented and discussed as well as the tool of method and data triangulation. The analysis is based on triangulation of different methods of rural appraisal, including standardized questionnaire, Participatory Rural Appraisal (PAR) and the sustainability analysis RISE (Response-Inducing Sustainability Evaluation).

Finally, in chapter five, the case study of Makrugbeh in Northern Sierra Leone is introduced. First, a brief introduction of the region of the humid tropics and its ecological constraints as well as of the challenging post-war situation of Sierra Leone is given. Then, the empirical findings of the vulnerability and sustainability analysis are presented. Focus lies on the vulnerability of rural poor households to climate change and food insecurity and the potentials of sustainable farming in reducing the baseline vulnerability as well as in strengthening coping and adaptation capacities in this regard.

The sixth chapter expands the findings of the case study analysis on broader spatial and thematic scale: The potentials for sustainable agriculture in the region of the humid tropics are discussed with regard to climate change mitigation and adaptation. Finally, sustainability is discussed as cross-sector and multi-level approach. The seventh chapter sums up the main objectives and findings of the thesis.

2. Introduction to the theoretical frame

2.1 Global Change and sustainable development

2.1.1 Three components of global change

The Philippine baby, our seven-billionth fellow citizen, is born into a changing world. Of course, the ecological, political and socio-economic face of our earth has always been changing. However, the current mass of parallel advancing processes and the spatial expansion of interactions are breathtakingly intensive. The daily media is full of headlines about processes like climate change, population growth, migration flows, environmental degradation and international economics. Political, scientific and civil society bodies publish reports on these developments and highlight challenges as well as potential adaptation and coping measures.

The complex system of interlinked processes and changes can be summed up under the term *global change*. Although the term global change is used inflationary, there is no common agreement on a practical definition. Trials to sum up all different processes and linkages, global change is embracing, will always be rather general. According to respective aim and objectives, a definition of global change needs to be adapted to the specific case.

In some cases, global change is being referred to as global environmental changes (Brauch et. al. 2010, WBGU 2005), such as climate change, soil and land degradation, pollution of water and air or loss of biodiversity and natural resources. These are however highly linked to human activities worldwide and need to be considered in combination. For this work, special interest lies in the human-environmental linkages within global change. The following definition of *global change* shall provide a working base for further explanation and the analysis of this work:

> Global change describes the present mass of developments on global scale, including economic, political, social and environmental processes. These changes are interlinked to a high degree. The complete set of global changes can be divided into three main components: Global environmental change, globalization and global mankind change.

Global change in the writer's perception consists of three different components that do partly overlap and that are building a complex intertwined system (figure 2): (a) Global

environmental change with climate change as central component; (b) Globalization[2] with economic and political focus, embracing processes such as advancing economic and political integration, increasing international trade and services, socio-cultural assimilations as well as processes of fragmentation; And (c) *global mankind change*. The term global mankind change shall subsume processes on global scale with regard to changes in human use of resources. It covers changes in modes of production, changes in consumption patterns and other changes in human lifestyle. Examples for global mankind change are: Advancing industrialization with increase in general productivity, increasing use of natural resources such as minerals, wood and water; increasing use of energy, mainly gained from fossil fuels; changes in diets, including the increasing demand for (animal protein rich) food; changes in mobility patterns with expanding use of means of transport. These processes can be generalized: We – the humans - are becoming more in number, we are producing more, we are consuming more, we are using more natural resources and we are producing more waste than ever before.

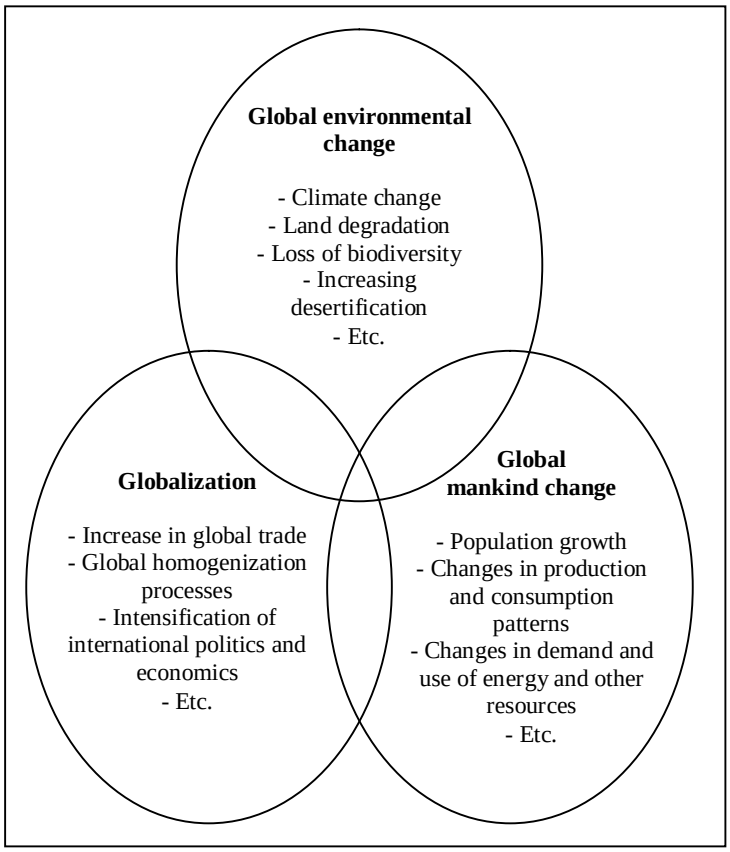

Figure 2: The three components of global change.

[2] There is no general accepted definition for globalization and in other studies and contexts the term might be used differently. For this work the understanding of globalization is based on the description by Nuscheler (2005:52ff.) including expansion in spatial scale and speed of (global) economic interactions, as well as cultural, social and political assimilation processes on global scale.

The overlaps of these three components content a series of different factors and processes: (a) Global mankind change is related to global environmental change through increasing demand in and use of natural resources due to population growth and changes in lifestyle. This affects ecosystems and its functions and services, what has reverse impact on global human livelihoods. Alterations in the global ecosystem, like land degradation and climate change, influence the living conditions of many people worldwide. (b) Increasing globalization in terms of political and economic changes affects global mankind change by fostering mobilisation and communication patterns among others. On the other hand, global lifestyle changes induce increasing global communication and trade and hence affect homogenization and cooperation on political and economic level. (c) Finally, The linkage between globalization and global environmental change is reciprocal, too: Globalization with its secondary effects has an impact on global ecosystems and the environment through increase in pollution and emissions, for example due to rising transportation in the global trading system. In reverse, the rising importance of global issues of environmental threats and challenges strengthen the need for joint global political decisions and cooperation.

These changes in ecological, economic, political and social dimensions occur on general, global level. The respective local characteristics differ significantly, depending on spatial as well as social location. These processes of global change constitute a complex system of human-environment interactions. In most cases it is not possible to identify linear, clear causal dependencies; the relations are too manifold and too intertwined.

2.1.2 The need for sustainable development

Since several decades, processes of global change are being discussed in academic and political circles with regard to the *limits on growth*. One prominent scenario was introduced already in 1780 by economist Malthus (see James 1989), stating that a world population, growing continuously like presently, exceeds the capacity of global food production. He argues that the difference in exponential population growth and linear food production increase would come to a point, where it is mathematically impossible to feed everybody. Although his thesis has been criticised and revised repeatedly, the underlying message is still present: More people on earth require more food and thus more land and other resources; and this increasing demand might exceed the carrying capacity of our globe. The discussion on the World Population Day 2011 with regard to our world population of over seven billion can be linked to the Malthusian thesis.

The increasing demand in food quantity and the consequently rising food production require more and more (natural) resources. Also, the way of food production and processing as well as human activity in general contribute to a reduction and overuse of natural resources, speeding up processes of land degradation and destruction of eco-systems. Recent studies are warning about peak oil, or even – maybe a bit strikingly – *peak everything* (Heinberg 2007), indicating that basic resources we humans consume, most prominent fossil fuels such as oil, are non-renewable. Or put differently: They are to some extent not regenerative and not available in the future to the amount we humans are demanding it presently.

It is evident that only sound and adapted alterations in global change processes can sustain our eco-system earth and hence our global human livelihood. A lifestyle as presently and *business as usual* is not suitable any more: We need sustainable development.

The Malthusian hypothesis can be seen as initial part of sustainability research, although the term *sustainability* itself was introduced not earlier than 1972: On the Earth Summit in Rio de Janeiro, the world community discussed the challenges for global society in the 21st century and plead for a sustainable development. They conceptualized the Agenda 21, integrating different challenges and potentials for sustainable development in an action plan[3]. The Club of Rome published a report on the "limits on growth", stating that we need to act soon in order to sustain our global system (Meadows et. al. 1978). Business as usual is no longer acceptable. The so called Brundtland report of the World Commission on Environment and Development (WCED) focussed more on the environmental issues of sustainable development and ways of sustainable resource management (WCED 1987).

Sustainability and sustainable development is nowadays central part of development project planning and implementation world- and sector-wide. The introduction of the Millennium Development Goals (MDGs) with the Millennium Declaration in 2000 is one example of the global community trying to embrace this issue holistically[4]. Still, the approaches are not yet sufficiently applied in development cooperation.

The term sustainability is being used inflationary, however, it is not a term with fixed definition, and respectively its understanding can be adapted for different purposes. This leads to fuzzy descriptions and the use of the term sustainability as *buzzword*.

[3] see <http://www.un.org/esa/sustdev/documents/agenda21/english/Agenda21.pdf> (acc. Nov. 2011).
[4] See <www.undp.org/mdg> for further information.

For this work, the underlying understanding of sustainability is based on the three-pillar approach[5] and the concept of strong sustainability[6], including following definition from the Brundtland Report: *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs* (WCED 1987:43)*."*

This approach includes inter-generational as well as present-day, intra-generational responsibility. Sustainable development is inevitable in order to channel global change processes in a fair and equitable direction for everybody. However, presently the situation is showing a different face, with several development challenges and livelihood insecurities within developing countries and marginalized groups of people. Existing inequalities are rather being strengthened instead of overcome.

Poverty and food insecurity are amongst the most pressing issues with regard to global change and sustainable development. According to latest reports of UNDP (2011) and The World Bank (2010), the number of people living in extreme poverty and suffering from food insecurity is increasing, although the world community is attempting to reduce its occurrence since several decades. Recurring hunger crises and famines arise especially in countries with low general development status, often combined with political instability. The causes of hunger crises need to be investigated holistically: A complex system of environmental, political, social and economic processes on local as well as on over-regional scale contribute to insecure livelihood systems and lead to structural poverty and hunger. The respective causal linkages depend on the specific case and region.

Global environmental change processes increase the challenges for sustainable poverty reduction and food security. The World Development Report (WDR) of 2010 of the World Bank is focussing on the linkages and interdependencies between development and climate change. There is a huge contradiction between non-braked climate change and sustainable development. It is argued that climate change is endangering already achieved developments and, that decisions on global political and economic platforms needs to adapt to changing climatic conditions, linked to changing vulnerabilities and migration patterns (World Bank 2010).

[5] The three pillars of sustainability are: ecological, economic and social sustainability. This concept is widely used in academic circles.

[6] In a strong sustainability approach, trade-offs in environment and natural systems can not be balanced by success in one of the other pillars (e.g. through compensation payments if eco-systems are destroyed in building processes). This would however be possible in a soft sustainability concept.

It is not easy to identify clear causal structures for poverty, underdevelopment or food insecurity. However, in many cases poverty and food insecurity are highly related to land issues and land-use patterns. Land and the ways how it is being used is a central part of the complex system of global change. The manifold connections between land and other factors of global change are introduced in the following.

2.2 Focal role of land and agriculture

2.2.1 General observations

Land[7] can have completely different value, based on its location and other factors, such as exposure, slope, vegetation cover and soil characteristics. It can be composed of natural eco-systems or it can be under anthropogenic use. Possibilities for human use of land are manifold: For building construction (infrastructure, public or private buildings, etc.), for industry, for extraction of mineral and other resources, for recreation and the tourism sector or for agriculture. Frequently, different interests in land-use exist in competition with each other, especially in regions where land is scarce.

Central anthropogenic way of land-use is agricultural production. Presently, more than one third of land area is under agricultural use worldwide (FAO 2006). Agriculture in its basic meaning is using arable land for field crops production (be it for food, fibre, fodder or fuel) or livestock husbandry. Cannon (2002:350) provides interesting insight in how perceptions of agriculture and its valuation differ among different groups of people: As the subsistence farmer will strengthen the importance of agriculture for food production and household security, the national government might have a broader perception, adding issues of political stability, tax revenues and potentials for foreign aid and investment to food security. The international business sector is focussing on potential profits and also farmers with highly intensified and large-scale production perceive their farm as business; in some cases (farmers in the EU) even for obtaining subsidies. According to different perceptions, different value is given to arable land, agricultural production and its products.

Many people depend economically on agriculture as main or even single source of income and commodities. Agricultural products are needed throughout: Food, fibre for construction works, fodder for cattle and fuel for cooking and other energy-demanding activities.

[7] In this work the term *land* is used as purely territorial and spatial category. It is not linked to attributes such as arability.

For this thesis, the primary objective of agriculture is seen in food production: To produce eatable field crops and fodder for animals that provide milk, fat and meat. But arable land can also be used for production of so called biofuels[8], especially biodiesel and bioethanol. With regard to competing interest in arable land, the issue of access to land and land rights are of essential concern[9].

Depending on the respective way of arable land-use, other sections of global change are influenced. Furthermore, global change processes have a reverse impact on land and its characteristics. Figure 3 indicates the connections of agriculture with global environmental change and global mankind change.

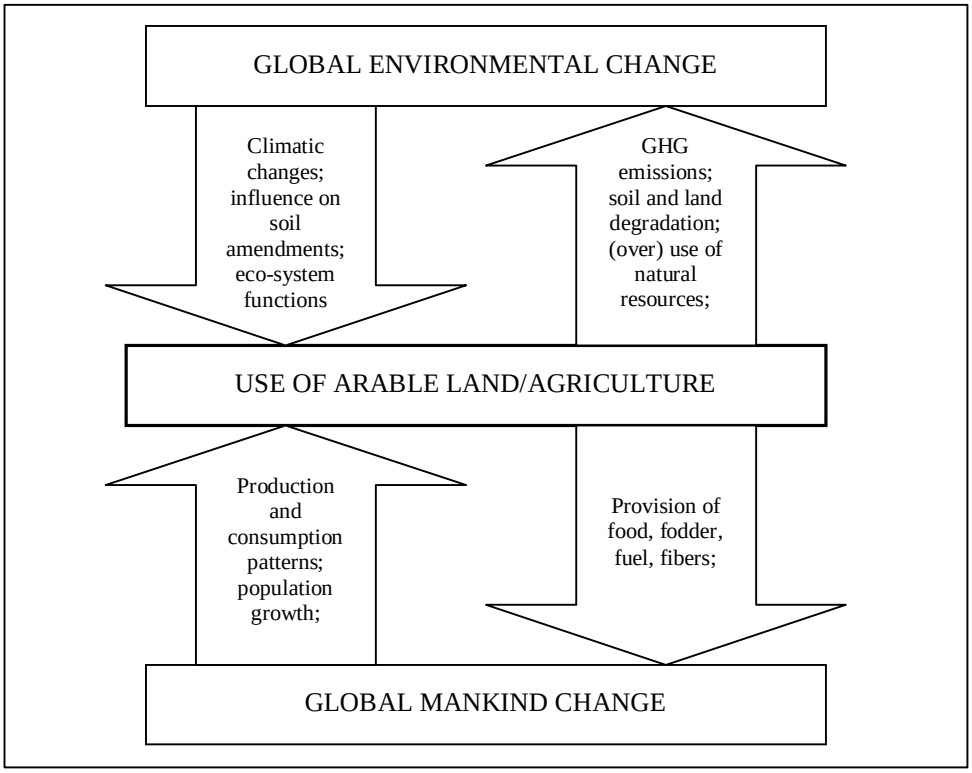

Figure 3: Interdependencies of agricultural land-use with global environmental change and global mankind change.

Global change processes with impact on rural livelihoods are population growth and therefore increasing demand in food and other agricultural products, global

[8] Biofuels are defined by the FAO as *"fuel[s] produced directly or indirectly from biomass such as fuelwood, charcoal, bioethanol, biodiesel, biogas (methane) or biohydrogen"*. (Source: <http://foris.fao.org/static/data/nrc/CCpdfglossary.pdf>, acc. Nov. 2011).

[9] In this work land-rights debates and issues of access to land are not included in the analysis. For further information see Baxter (2010), Kabba/Li (2011), Mousseau/Sosnoff (2011) and Unruh/Turray (2006) with regard to land-tenure system and FDI in land in Sierra Leone.

environmental changes, e.g. climate change, rises in agricultural input costs, volatility of food prices (Wisner et. al. 2008:80).

As the focus of this thesis lies especially on the connections between agriculture, food production and climate change, these interdependencies are discussed in more detail in the next section.

2.2.2 Agriculture, food production and climate change

As more and more evidence is coming up that the enhancement of global greenhouse effect can be traced back to anthropogenic performance, it becomes increasingly obvious how strongly related natural and human systems are. Climate change embraces the overlapping border of pure natural, eco-systems with human livelihoods. Humans are part of the global eco-system and their livelihoods and life-style is highly connected to changes in the atmosphere. Central observations and predictions as well as potential adaptation and mitigation measures are presented in the fourth assessment report of the International Panel on Climate Change (IPCC) from 2007[10]. Climatic changes have an impact on natural eco-systems as well as on human livelihoods. In general the following climatic changes and impacts are predicted worldwide (WBGU 2008:59ff.): Rising of global mean temperature, changes in precipitation patterns, intensification of tropical storms and hurricanes and sea-level rise are affecting availability of water, vegetation and land-use patterns and other socio-economic factors of human livelihoods. Different research organizations use different models and scenarios for their calculations and models, thus predictions of changes in CO_2-concentration in the atmosphere in the coming decades and their impact can differ.

With regard to climate change, agriculture is a potential sector for a variety of mitigation as well as for adaptation measures. The IPCC states that *"[a]lthough responses to recent climate changes in human systems are difficult to identify due to multiple non-climate driving forces and the presence of adaptation, effects have been detected in forestry and (…) agricultural systems* (Parry et. al. 2007:81)". The relation between agriculture and climate change is reciprocal: On the one hand the agricultural

[10] However, looking at findings from the IPCC it is important to note that *"[w]hile there is now significant evidence of observes changes in natural systems in every continent, including Antarctica, as well as from most oceans, the majority of studies come from mid- and high latitudes in the Northern Hemisphere. Documentation of observed changes in tropical regions and the Southern Hemisphere is sparse* (Parry et. al. 2007:82)". Hence, there is an imbalance in availability of studies from different regions and eco-zones, leading to differences in representativeness and significance of its explanations. None the less the report provides incomparable deep insight in present research on climate change worldwide.

sector is one major source of greenhouse gases. Presently 17 percent of greenhouse gas emissions come from agriculture, another 14 percent from the forestry sector (CGIAR 2009: 40). Main sources are cattle breeding, wet rice production, as well as certain kinds of land-use change such as deforestation and wetland dewatering. On the other hand, climate change has several direct as well as secondary effects on agriculture, due to the strong dependency of agricultural performance on climatic conditions. Nevertheless, it is not easy to identify clear causal structures, because many other factors can have an impact as well. Among them: Anthropogenic performance and agronomic practices, like the use of chemical fertilizer, pesticides, heavy machinery and others.

According to Downing, global climate change affects agriculture in different ways, as it "*may: lengthen the growing season due to higher temperature; reduce soil moisture due to increased evaporative demand (with or without changes in precipitation); accelerate early plant growth and reduce periods for grain filling; affect the partitioning and quality of plant biomass; affect crop pests and diseases; and entail spatial shifts of agricultural potential* (1991:368)". The following primary impacts of climate change on global agriculture can be summed up in the following (see Parry et. al. 2007:98ff.): Changes in crop phenology, hence the timing of seasonal activities, like flowering, leave development, fruit development etc. often require adaptation of farming practice and timing. Additionally, changes in climatic conditions have an impact on the distribution and phenology of pests and diseases, too. Yield loss is predicted with rising temperatures, connected to increasing water scarcity in dry areas. On the other hand, rising temperatures in higher latitudes can contribute to longer vegetation periods and thus to an increase in yield.

Further, secondary impacts on global agriculture can be expected based on the following processes and factors: Changes in soil amendments and characteristics are inevitable through rising temperature and thus increasing or changing weathering processes. This is influencing soil properties, such as water holding capacity, nutrient availability, base saturation and other physical and chemical characteristics. Additionally, global arable land is degrading, e.g. through sea level rise and droughts, reducing the availability of fertile land per capita.

All these processes mentioned above have direct or indirect, negative or positive influence on crop performances and yield. The effect depends on the locality and the special features, such as climatic adaptation capacity of crops etc. Downing (2002:371) gives several examples on how agricultural systems are of concern with regard to

climate change: Depending on the respective scenario and its underlying expectation of global warming, global food production is in threat of decline, influencing national agricultural trade systems. Consequences could be economic loss, increasing food insecurity and other, long-term impacts. In the next chapter the challenges for rural poor farmers with regard to climate change and their vulnerability to food insecurity is discussed.

2.3 Vulnerability of rural poor to climate change and food insecurity

The sensitivity of agriculture to changing climatic conditions differs according to respective eco-system and agro-zonal characteristics. Linked to that, locally specific vulnerabilities of human livelihoods to food insecurity exist.

There is no common accepted definition of vulnerability in the context of sustainability studies and development research. Depending on individual scientific aims and objectives, several different concepts of vulnerability are applicable. For example, vulnerability can be understood as "*the degree to which a system, subsystem, or system component is likely to experience a harm due to exposure to a hazard, either a perturbation or stress/stressor* (Turner et al. 2003a:8074)". In contrast to that, Wisner (2008) limits vulnerability to individuals or to a group of persons, whereas material things or complete systems can be insecure or weak, but not vulnerable. In this work vulnerability shall be defined as following:

> Vulnerability describes the characteristics of a human livelihood system that constitute its ability to anticipate, resist, cope with and recover from the impact of natural hazards and other stress.

A central group of vulnerable people - also with regard to climate change - are the ones living in (extreme) poverty. In this work, poverty is seen as holistic concept, including factors of economy, health, education, social and political participation. The term will be used in the following, including this variety of dimensions of poverty by WGBU (2005:38ff.).

Social vulnerability is related to poverty through the occurrence of unequal distribution of vulnerability and risks amongst group of people. The IPCC defines the poor as especially vulnerable group, "*because of their limited access to profitable livelihood opportunities and limited access to areas that are fit for safe and healthy habitation* (Parry et. al. 2007:489)". They conclude that "*protection from the social forces that create inequitable exposure to risk will be as important if not more important than*

structural protection from natural hazards in reducing vulnerability of the poor (Parry et. al. 2007:489)".

Agriculture is a highly vulnerable sector of human activity to climate change. On the one hand, agricultural performance can increase vulnerability (agriculture is main source of income and food), because it is very vulnerable to climatic changes and it needs land and water and other resources that are becoming more and more scarce with global change. On the other hand, it offers several possibilities of adaptation measures and for a more sustainable livelihood. The vulnerability of land and people using the land and also the potentials for adaptation depend on the local context and the specific environment. "*In some parts of the world, the livelihoods that people have available to them (using existing technologies and cultural preferences) are inherently liable to fluctuations and inadequacies, and therefore have a recurring risk of hunger* (Cannon 2002:349)."

Summing up, rural poor livelihoods can be identified as especially vulnerable to climate change. In his analysis of the impact of climate change on agriculture and food security in Africa, Downing concludes that with changing climatic conditions "*global food production can be maintained at the levels that would have been achieved in the absence of climate change, but possibly with greater costs. Regional food shortages are likely, due to variations in climate and resource capacity, population growth, and economic and political development. (…) National food poverty will depend on changes in yields, cultivated areas, and ability to import food. (…) For households, the key may be the structure of the economy. Some socioeconomic groups (…) may benefit from greater producer prices*" (1991:377f.). Hence, poor farmers need strong support and safety nets in order to balance these future challenges of increasing food insecurity through climate change.

In the assessment report of the IPCC, regional specific sensitivities and vulnerabilities to climate change are summed up, amongst them Africa (Parry et. al. 2007:433ff.). By analyzing hotspots for risk areas in Africa, several countries are attributed with high risk to drought related mortality as well as high vulnerability to food insecurity (under-nourishment and malnutrition) with regard to climate change. The agricultural sector is seen as central sector for African economy and basis for several livelihoods. Main climate change impact is coming from climate variability increase, aggravating natural-resource challenges, such as poor soil fertility, pests and crop diseases and lack of access to seeds and farm inputs. Scenarios assessing the climate change impact on the

African continent predict differences according to different regions and sectors of agriculture. For West and Central Africa main current and future predicted impacts and vulnerabilities for the agricultural sector are according to Parry et. al. (2007:451): Impacts on crop performance leading to possible loss of agricultural GDP; The population of West Africa living in coastal settlements could be affected by projected rise in sea level and flooding; And changes in coastal environments (e.g. destruction of mangrove forests and coastal degradation) could have negative impact on the fishery and tourism sectors.

In order to find solutions to reduce the vulnerability of rural poor households to these climate change impacts, it is necessary to have a closer look on the potentials of sustainable agriculture.

2.4 The potentials of sustainable agriculture

2.4.1 General introduction

Sustainable development on different spatial and thematic levels is essential for overcoming negative effects of global change. Consequently, sustainable agricultural production can contribute to reducing poverty and balancing food insecurity.

One central solution for the bundle of challenges for rural poor households in the context of global change lies within the adoption of sustainable agronomic practices. In this section different approaches of how a sustainable agricultural use of land and other resources can be implemented are being presented.

Different research organisations and international think-tanks offer different approaches of how sustainable agriculture can be defined, implemented and achieved[11]. Key components of these approaches are:

- Integration of ecological as well as socio-economic factors in the concept of sustainability
- Focus on locally adapted agronomic practices, local potentials and resources
- Avoidance or minimization of external input

For this work the understanding of sustainable agriculture[12] is based on the central IFOAM principles.

[11] Examples of different approaches are LEISA (low external-input sustainable agriculture) or integrated farming.

[12] In this work sustainable agriculture/farming will be used synonymously with organic farming/agriculture.

The four principles of organic farming according to IFOAM are:

"Principle of health: Organic Agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.

Principle of ecology: Organic Agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.

Principle of fairness: Organic Agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities

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 (see IFOAM 2011)*."*

These principles are quite general and their combination offers a holistic understanding for a sustainable way of farming, independent of regional differences in climate, soil conditions and socio-economic situation. Thus, it is applicable worldwide in every eco-zone independent on the present way of farming. With these principles IFOAM does not imply specific agronomic practices or forbid certain methods, like the use of chemical fertilizers, just like that. It is necessary to look into the specific case, work out regional problems and potentials and create a locally adapted organic agriculture based on the presented principles.

Similarly, the FAO provides a definition that will build the basis for the case study, by stating that *sustainable farming and rural development* is a process, that:

"- Ensures that the basic nutritional requirements of present and future generations, qualitatively and quantitatively, are met while providing a number of other agricultural products.

- Provides durable employment, sufficient income, and decent living and working conditions for all those engaged in agricultural production.

- Maintains and, where possible, enhances the productive capacity of the natural resource base as a whole, and the regenerative capacity of renewable resources, without disrupting the functioning of basic ecological cycles and natural balances, destroying the socio-cultural attributes of rural communities, or causing contamination of the environment.

- Reduces the vulnerability of the agricultural sector to adverse natural and socio-economic factors and other risks, and strengthens self-reliance (FAO 1995)."

This definition draws a holistic picture of sustainable farming. For deeper insight in local conditions and for case-based assessments, further specification is necessary.

Figure 4 shows the three pillars of sustainability on farm-level, based on the IFOAM principles and the above definition.

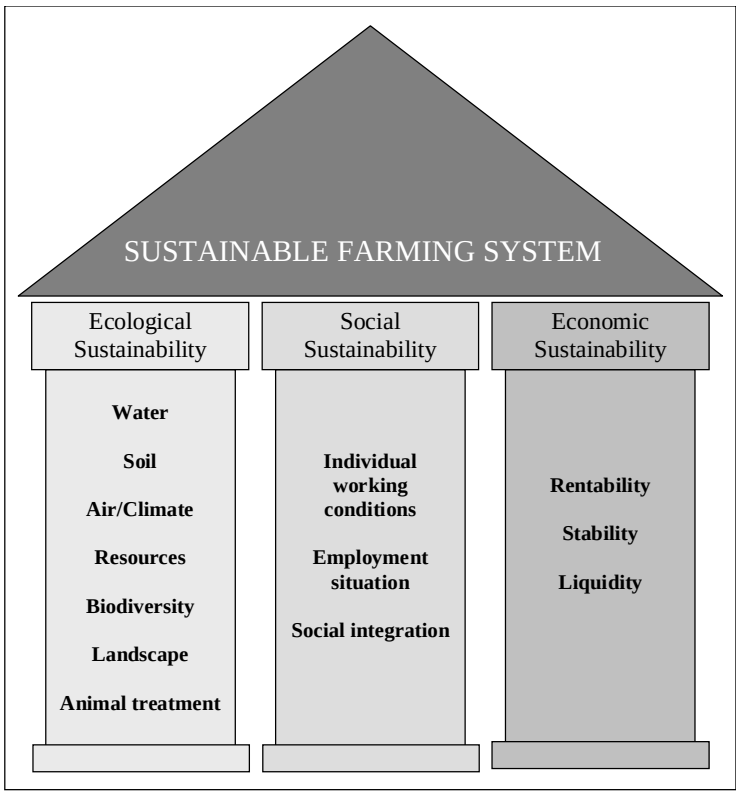

Figure 4: The three dimensions of sustainability on farm-level (Source: Zapf et. al. 2009).

The ecological dimension of sustainability on farm-level contains sustainable use and protection of natural resources as well as hygienic waste and waste water management, as well as acknowledgement and protection of eco-system functions and services and adequate treatment of animals. In the pillar of social sustainability fair working conditions with adequate payment or other compensation is important next to social integration on different levels, such as age, gender and social class. Economic sustainability of a farming system is given if the farm management is rentable, stable and liquid up to an adequate degree. The respective *adequateness* depends on the regional socio-economic and political framework (Zapf et. al. 2009:404ff).

If this threefold sustainability is provided on farm-level, the farming system offers potential for decreasing vulnerability to food security and adaptation to climate change.

2.4.2 Sustainable agriculture and food security

The first bullet point in the FAO's definition of sustainable agriculture strengthens its importance for adequate food supply. There is hence a relation between the degree of sustainability on farm-level and food security. Before a closer look at this connection will be given, the term *food security* shall be introduced in more detail.

Oswald-Spring (2009) states, that food security is one of the central human and livelihood challenge in global environmental change. Definitions of food security changed significantly over the past decades, partly parallel to shifting paradigms in development research and the respective global political situation. An initial approach, developed at the World Food Summit 1974, defines food security as "*availability at all times of adequate world food* ***supplies*** *of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices* (United Nations 1975, strengthening by the writer)". The focus obviously lies on the stabilization of food supply on a global scale. The FAO introduced a crucial aspect in 1983 by adding the condition: "*ensuring that all people at all times have both physical and economic* ***access*** *to the basic food that they need* (FAO 1983, strengthening by the writer). This expansion draws more attention to the importance of access to food and to differences in vulnerability. With its report "Poverty and Hunger", the World Bank 1986 introduced the distinction of chronic and transitory food insecurity (quoted from FAO 2003). Chronic food insecurity is caused by structural problems and chronic poverty, whereas transitory food insecurity arises in times of natural disaster, or economic and political pressure. With time, a differentiation of local, individual and global food insecurity came up. Furthermore, the distinction of food security and nutrition security was established: Nutrition security includes - next to the availability of the adequate quantity of food - that the quality and nutritious composition of food is highly important in order to sustain a healthy life. Finally, in 2002 the following definition was published by the FAO in "The State of Food Insecurity in the World 2001": "*Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.*" New emphasis is given now to the issue of a threefold access to food as well as to the importance of adequate food quality and composition, next to its quantity. Based on that understanding, it becomes obvious that global food security is not just connected to the total amount and the quality of produced food, but also on global distribution patterns. And these are highly related to economic and

political issues[13]. The three central components of food security are presented in figure five.

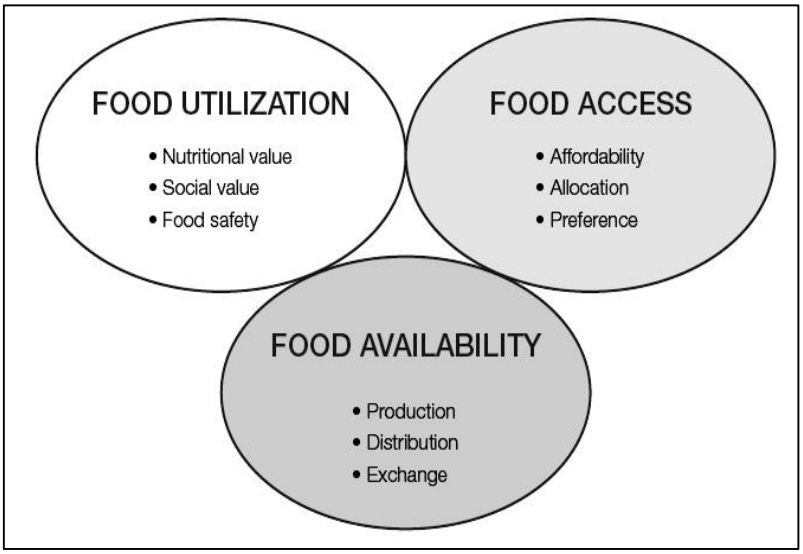

Figure 5: The three components of food security (Source: CCAFS/CGIAR 2009).

Agriculture and land-use patterns are connected to food security in different ways, according to this figure: Agriculture is the primary source of food production and hence is partly securing food availability. Furthermore, the nutritional value of food and food value depend on agronomic practices. Thus, agriculture is also connected to the factor of food utilization. In general, the way of farming and the implementation of specific agronomic practices is having an effect on global food availability and especially on regional availability of food.

Some studies indicate that the conversion from conventional intensive farming to sustainable farming will lead to a decrease in yield per hectare. In a world where there is already a food shortage in several regions, these developments would increase the challenge of eradicating hunger worldwide. However, others claim the opposite, saying organic farming worldwide has the potential to decrease food security. Both opinions are considered in the following.

Niggli/Fließbach (2009) focus on the differences between conventional and organic farming with respect to its impact on global food security. They state that the expected yield loss through conversion to organic farming depends on the eco-zone and the

[13] The *UN Forum for Indigenous Peoples* includes further social and cultural factors in their concept of *food sovereignty*, defining it as *"the right of Peoples to define their own policies and strategies for the sustainable production, distribution, and consumption of food, with respect for their own cultures and their own systems of managing natural resources and rural areas, and is considered to be a precondition for Food Security"*. See <http://www.treatycouncil.org/new_page_5241224.htm> (acc. Nov. 2011) for further information.

original farming system. In regions where traditional, extensive farming methods are used, the shift to sustainable agriculture could increase yields; whereas the change of conventional, intensive - “modern”- agriculture to organic farming would in most cases decrease the total quantity of yield per hectare. However, there is no clear evidence of how organic farming can improve or worsen food security in specific localalities, especially with regard to SSA due to lack of significant number of scientific studies (Grenz/Sauerborn 2007:52).

Next to the quantity of produced food, its quality is also important (Weingärtner et. al. 2011). Sustainable produced organic food can have higher nutritional value than conventionally produced one (e.g. because of no use of chemical fertilizer and other inputs). The demand of good quality organic food is rising globally. Due to regional support mechanisms and certification, this leads partly to a price advantage for the producer. The conversion to organic farming does not automatically lead to a decrease in income, although it can lead to yield decrease. However, challenges still arise in terms of quality control and certification. Furthermore, a decrease in global yield of food products does not lead automatically to an increase in food insecurity, because it is also a matter of how the food products are being distributed. Nowadays, global food production exceeds food needs, but still many people don't have sufficient access to it. This leads to an over-supply in (mostly) industrialized countries and to a lack of supply in developing countries. In the former, the surplus is being dumped, whereas in the latter, people suffer from food insecurity and hunger crises (Weingärtner et. al. 2011).

Another issue of rising concern with respect to food security is the competition over (arable) land for different purposes. A newly evolving sector of large-scale, commercial arable land-use is the production of biofuels. The demand for energy in form of biofuels as replacement of fossil fuels is increasing. The mono-cultural and large-scale production of biofuels competes with increasing demand in food products all over the world (BfdW et. al. 2010). This is worth keeping in mind especially with regard to climate change: On the one hand, biofuels are praised to be a more ecologically sustainable alternative to fossil fuels for mitigating climate change. The European Union highly supports and focuses on increasing the use of biofuels in the transport sector. On the other hand, the mostly mono-cultural production is not sustainable in the long run with regard to soil nutrient availability and other ecological factors.

Additionally, biofuels production is often linked to cases of so called *land grabbing*[14]: Traditional land-users, often subsistence farmers without official land possession documents, loose their land to international biofuel-companies that have specific agreements with governmental bodies. The produced biofuels are being exported, and the farmers often face lack of alternative income sources and eventually food insecurity. It is inevitable to perform biofuels-production in a sustainable manner without comprising the sustainability of livelihoods of the local population (see WBGU 2009). More insight in the connection between climate change and organic farming is being given in the following chapter.

2.4.3 Sustainable agriculture for climate change mitigation and adaptation

With regards to climate change, agriculture offers a wide range of mitigation and adaptation possibilities, as introduced earlier: Main sources of greenhouse gases from the rural sector are cattle breeding, wet rice production, land-use change (e.g. the drying up of swamps and peat lands) and deforestation. Minor production of carbon dioxide is coming from the production of chemical fertilizers and pesticides as well as through (natural) soil erosion. According to Downing (1991:378) "*the ultimate effect of climate change on agriculture and hunger will depend on the effectiveness of adaptive responses on several scales. Small changes in climate may be readily accommodated by adjusting several types of agricultural practice: cropping systems, irrigation, soil conservation, timing of farming operations, crop varieties and types, and land uses*". Hence, agricultural production needs to be adapted to these changes in order to balance the impact of climate change and risk of food insecurity.

Sustainable agriculture can contribute in different ways to climate change mitigation as well as adaptation. Hirschfeld et. al. (2009), Niggli/Fließbach (2009) and Muller (2009) describe a variety of possibilities how organic farming is a useful tool in order to fight climate change and to cope with its impacts. In comparing conventional and sustainable agronomic practices, Hirschfeld et. al. (2009) indicate that the – rather hypothetical - conversion of total global agriculture to organic farming would halve the greenhouse gas emissions from the farming sector. However, they admit that some countries face the problem of lack of arable land for these changes, because in some eco-zones and environments the change from conventional farming to sustainable farming would lead to a higher demand of land for the same yield per hectare. They state that conversion to

[14] More information on the issue of land grabbing and several examples can be found in BfdW et. al. (2010), Mousseau/Sosnoff (2011) and WBGU (2009).

sustainable organic farming has several other positive ecological side effects, like the protection of biodiversity.

Mitigation possibilities of organic farming lie within emission avoidance on the one hand and carbon sequestration on the other (see Muller 2009:5ff.). The first is achieved through:

- Lower NO_2 emissions due to lower nitrogen input, e.g. through chemical fertilizer
- Less CO_2 emissions through erosion due to better soil structure and more plant cover
- And, lower CO_2 emissions from farming system inputs such as pesticides and fertilizers produced using fossil fuels

Soil carbon sequestration is enhanced through different agronomic practices, such as:

- Increased use of organic and green manure
- Intercropping and mixed cropping systems
- Inclusion of perennial grasslands, trees and hedges in landscape

Muller (2009:2) states, that the locally specific challenge for organic farming as adaptation strategy is a highly socio-cultural matter, meaning, it depends on existing livelihood assets and the capabilities of the farmer to develop and implement a suitable adaptation strategy. Imaginable measures are e.g. the increasing use of adaptive plant varieties, changes in agronomic practices, such as no- or low-tilling or application of green manure.

Several synergies between adaptation and mitigation measures are possible. For example, the reduction of removing harvest residues decreases the loss of soil organic matter and erosion on the one hand (mitigation) and can improve the soil nutrient status and general fertility on the other hand, what supports crop performance in general (adaptation). In general, the adaptation potential of sustainable farming lies in the increase of agro-eco-system *resilience* through conversion from several conventional farming techniques.

In any system situations can arise when its resilience is overwhelmed. Such events occur, when a system reaches a so called *tipping point*. A tipping point defines a pressure on the system on a certain point in time, which exceeds the system's coping capacity. Such a tipping point can arise due to a sudden event or a more creeping

process, putting the system under stress, not able of being balanced[15]. That means, a natural system with its specific composition of factors and processes is not able to balance back completely to its original state and will hence be changed irreversible. A new natural system with components and characteristics different than the original ones will develop over time. This new system will consequently be based on a new, system's specific resilience. This becomes a matter of human security as soon as the system we are talking about constitutes or is part of human livelihood. Imaginable tipping points where humans would suffer from the consequences are: Earthquakes that destroy infrastructure and buildings and change the physical face of the earth irreversibly; or eruption of volcanoes, covering the surroundings with lava and ashes; Additionally, humans as part of a system can contribute highly to the occurrence of tipping points with their lifestyle and activities.

Talking about climate change and agriculture, following tipping points concerning the global eco-system are predicted within the coming decades - if no significant mitigation measures are implemented successful. With increasing pollution of the atmosphere, the greenhouse effect will aggravate and global mean temperature will rise steadily. This enhances the melting of the poles and other glaciers. Scientists predict that the global eco-system will come to a tipping point when consequently sea water temperature is rising and the salt concentration in the oceans is changing more and more. These processes can have severe impact on global sea currents. Present water flows and directly linked atmospheric movements and winds would change direction or even die off and thus affect human and natural eco-systems all over the world (Kriegler et. al. 2009). In Africa, imaginable tipping points exist with regard to Western African monsoonal changes, related to the ENSO (El Nino Southern Oscillation) phenomena and global sea currents (The World Bank 2010:90).

These findings show the variety of challenges for farming systems in times of climate change and hence the plurality of possibilities for organic farming to contribute to climate change mitigation and adaptation. Especially in rural settings, where human livelihoods are highly dependent on arable farming activities, sustainable agriculture correlates strongly with vulnerability to climate change and food insecurity.

[15] Schellnhuber (2009) incorporates the factor of *tipping element* in his explanation of tipping points. Tipping elements are the specific subsystems that will be affected first by changing (climatic) conditions and hence experience first an overstrained system's resilience. A special feature of the PNAS offers insight in recent research on "Tipping elements in earth systems", see <http://www.pnas.org/content/106/49.toc#content-block> (acc. Nov. 2011).

Before introducing the methodology applied in the case study of Makrugbeh in Sierra Leone, the theoretical findings from the previous sections are summed up:

In rural poor settings, agricultural production plays a crucial role in human livelihoods. The main or even single source of income and primary source of food lies in agricultural production and in specific farming activities. This sector is highly intertwined in global change processes on different levels. The IPCC (Parry et. al. 2007:455) visualizes these linkages between climate change and the three major components of food security for the African setting (figure 6).

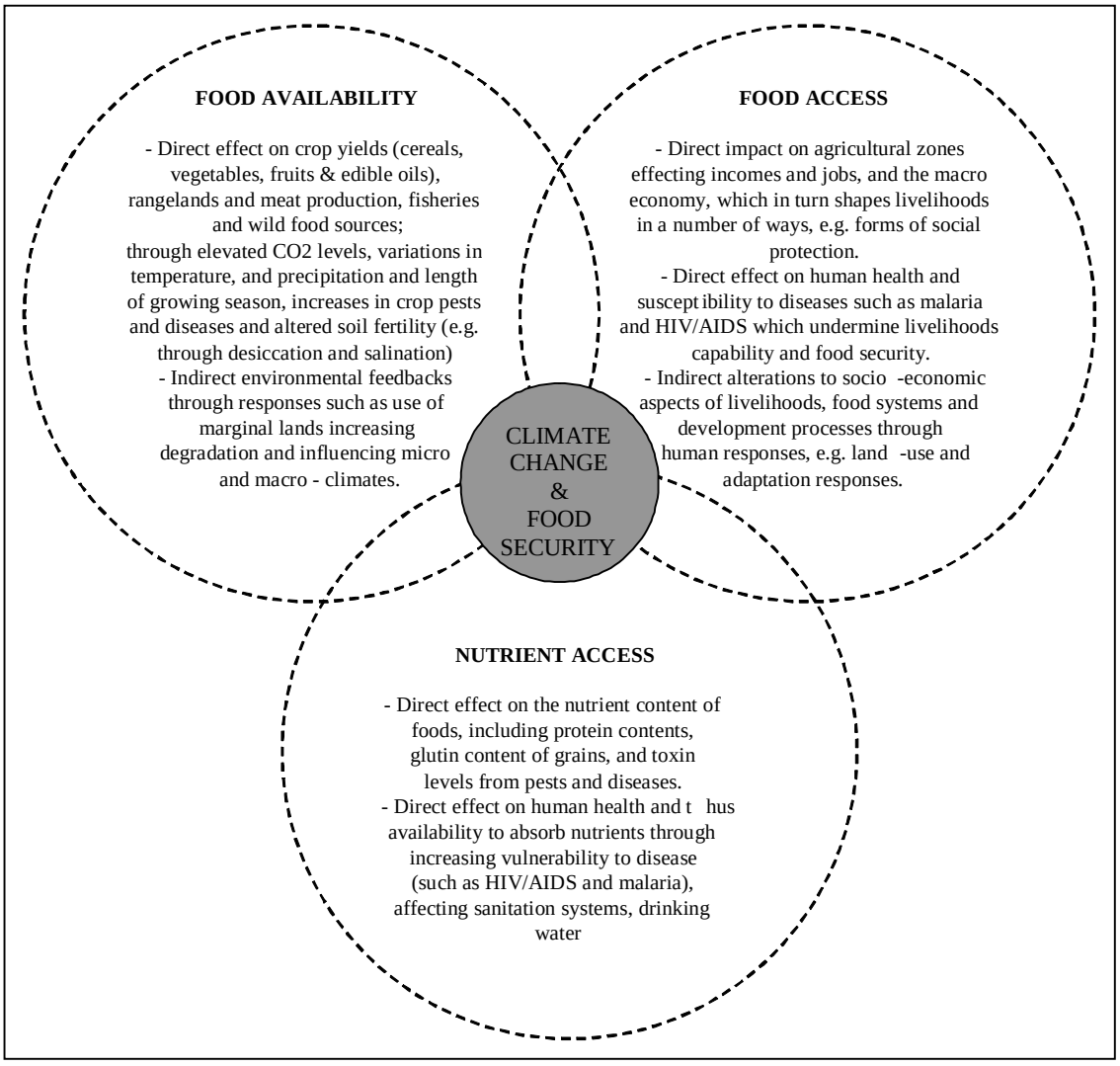

Figure 6: Linkages between climate change and food security in Africa (Source: Parry et. al. 2007).

Agriculture and especially crop production is one of the most vulnerable sectors to climate change; the most basic resource of agriculture is arable land, whose availability decreases due to (natural) loss of fertile land (land degradation, erosion, sea level rise)

as well as rising demand of land for other economic sectors (mineral sector, building construction, biofuel production). The general livelihood situation of rural poor households is characterized by different challenges like food insecurity, lack of access to basic livelihood assets, limited economic possibilities. Consequently, the general underlying poverty leads to a rather low coping and adaptation capacity of the livelihood towards stress and hazards. The vulnerability of rural poor households is therefore influenced by a multi-level, interdependent system of different causal structures and factors. Climate change research broadens the field of vulnerability and sustainability assessment in scope and depth. New threats for agro-eco-systems are coming up, such as the rising sea level. Furthermore, scientists predict the intensification of present natural hazards and extreme weather events, like storms and droughts. According to Schweatzer (2010:18) nowadays 75 percent of disasters triggered by natural hazards are weather-related extreme events. As disasters occur in combination of natural hazards with human livelihoods vulnerability, this number is not just related to increasing climate changes but also to increasing vulnerabilities. These predictions of stress and hazards are affecting natural and human systems regionally limited. None the less, it makes locally adapted vulnerability assessment with inclusion of improved climate scenarios inevitable. The more sustainable a rural poor farming system, the lower is its vulnerability to climatic changes and the risk of food insecurity.
This correlation shall be analysed for the case study of Makrugbeh in Sierra Leone. For the assessment a specific theoretical and methodological framework is designed. In the following chapter, different approaches of how to assess vulnerability and how to combine it with sustainability research are presented before introducing the research design for the case study.

3. Conceptualizing vulnerability and sustainability assessment

As indicated above, there is a multilevel connection between the sustainability of a human livelihood system and its vulnerability. Hence, in assessing the vulnerability of households to global environmental change and food insecurity in a holistic way, it is inevitable to include sustainability analysis in the research design. This chapter gives an overview of different approaches to assess vulnerability as well as sustainability of human livelihoods.

The first stream of vulnerability research, presented in the following, incorporates social science based approaches, whereas the second group focus on natural risk and hazard research, including a natural science perspective. Aspects from both streams will be included in the conceptualization of Vulnerability and Sustainability Assessment (VASA) for the case study. As central in sustainable development research, the Sustainable Livelihoods Approach (SLA) is described subsequently. Summing up, a plea for an integrated approach in global change research is presented and as conclusion to this chapter the theoretical model of VASA for the case study of Makrugbeh is introduced. As the case study is focussing on the vulnerability of rural poor households to global environmental change, climate change and food insecurity, each of the concepts presented will be discussed in relation to these issues.

3.1 Approaches of vulnerability assessment

Every system, be it a pure natural eco-system or a more anthropogenic influenced one, contains a certain vulnerability to different stress, risks and hazards. Several scientific disciplines make attempts from different perspectives and develop models for vulnerability analysis. However, this interdisciplinarity contains a certain challenge, as Dölemeyer (2010) points out: Different usage of key terminology in different scientific disciplines assessing vulnerability can induce misunderstandings. Therefore, before different approaches of how to assess vulnerability are being presented, the writer wants to clarify some central terms.

As defined above, in this work vulnerability is understood as the characteristics of a human livelihood system that constitute its ability to anticipate, resist, adapt to, cope with and recover from the impact of natural hazards and stress.

A hazard "*is a natural process or phenomenon (floods, storms, droughts, earthquakes) (…). Hazards differ in severity, scale, and frequency and are often classified by cause*

(such as hydro-meteorological or geological) (World Bank 2010:25)." Thus, (natural) hazards are primary purely natural phenomena that do not necessarily lead to destruction of human live or livelihood. They turn into a disaster, as soon as a hazard hits a vulnerable human system. However, the trigger event of a disaster can also be of political, social or economic origin, e.g. conflict and wars, economic crises or social marginalization (Bohle 1993).

A disaster is hence "*a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources* (UNISDR 2009)." Disastrous events that do not occur suddenly and abruptly but evolve over a certain period of time are called stress(ors) in the following. Stress consists mainly of political, social or economic processes. Finally, risk shall be defined as the expected probability of disaster occurrence after certain hazard(s) or stressors hit a vulnerable social system.

Based on the underlying definitions, concepts of how to assess and analyse vulnerability in a certain context differ as well. A variety of indicators, and explanatory structures is imaginable. Schwaetzer (2010:19) mentions the importance of interdisciplinarity in vulnerability research as causal relations between extreme events, the environment and human livelihood are extremely complex. It is inevitable to combine social science based findings with approaches in the natural sciences. Research and case study analyses from different scientific perspectives contribute to a better understanding of the underlying processes and could support political decision making.

The origins of vulnerability research lie within the risk-hazard research, identifying extreme natural events as causes for disaster, analysed with a one-dimensional impact analysis. Single natural events (e.g. droughts or flooding) are seen as cause for multiple negative outcomes (e.g. migration flows, hunger and economic loss). This perspective is criticised repeatedly as being too simplistic to incorporate the complexity of the global intertwined human-environmental system (Ribot 2010, Turner et. al. 2003a).

Concepts of social vulnerability focus on the socio-economic and political causes of vulnerability to food insecurity. This stream of poverty and hunger research is presented in the following.

3.1.1 Social vulnerability and famine research

There is no single direct link from poverty to food insecurity (thus: increasing poverty does not automatically increase vulnerability to food insecurity). However there is indeed a strong relation between these two factors. As presented in chapter 2.3.1 food security shall be defined as sufficient amount of food with adequate quality, to which all people have physical, social and economic access to, in order to live a healthy life. This definition is encompassed in one of the central concepts of vulnerability research in social science: The entitlement approach by Indian economist and Nobel price winner Amartya Sen (see Drèze & Sen 1989 and Sen 2001, 1997). He focuses on the role of individual possibilities of access to food, and the causal structures leading to the occurrence of famines. Basic component of his concept are *entitlements*, a set of assets and capabilities that every person enjoys. These entitlements are described as "*the commodities over which she [the person] can establish her ownership and command. People suffer from hunger when they cannot establish their entitlement over an adequate amount of food* (Sen 2001:162)". The individual entitlements are determined by endowment, meaning ownership over material and human resources; by production possibilities, saying by access to technology and knowledge; and by exchange conditions, such as the ability to purchase and engage in trade. This set of determinants is influenced by the socio-economic and political context the individual is embedded in. Sen's focus of interest is the economic frame, influencing entitlements with regard to food insecurity. "*Understanding the causation of hunger and starvation calls for an analysis of the entire economic mechanism, not just an accounting of food output and supply* (2001:164)."

He criticises the common reduction of poverty to *income poverty*, excluding other factors that lead to a deprivation of basic capabilities, such as unemployment, inadequate health care system, lack of education or social exclusion (Sen 2001).

As practical guidance for vulnerability assessment, Sen states that "*[t]he focus has to be on the economic power and substantive freedom of individuals and families to buy enough food, and not just on the quantum of food in question* (2001:161)". However, he does not include the factor of adequate nutritional food value.

Sen's entitlement approach is central in the vulnerability and famine research. Nevertheless, it has been criticised repeatedly (see Baro/Deubel 2006, Mukherjee 2004, Watts/Bohle 1993). Central aspect of criticism is Sen's focus on market-based processes and economic causes of vulnerability and entitlement decline. It is argued that its

concept "*neglects the salience of politics, historical processes, and social disruption in creating conditions of vulnerability and famine* (Baro/Deubel 2006:524)". Based on these aspects, expanded concepts have been developed, often including central features of Sen's entitlement approach.

Watts/Bohle (1993) use the key elements of Sen's concept as one factor of their model of the *space of vulnerability*, for analysing the causal structure of hunger and famine. They expand Sen's entitlement approach by including two additional pillars of vulnerability: Political empowerment and the role of social classes. Bohle (1993, 2003) focuses, accordingly to Sen, on the vulnerability of households to food insecurity, or as he calls it, to *food poverty*. For vulnerability analysis he offers a simplified figure, showing the transitory character of food crises: Every system has a certain baseline vulnerability (to food insecurity), based on socio-economic and political structures. If a trigger event or a causal chain of events hits the system and the baseline vulnerability is overwhelmed, a food crisis occurs that might even transform into a famine disaster. Depending on the system's internal coping strategies as well as external interventions, a process of recovery is evolving. The outcome is quite unpredictable: The system needs to adapt to the long-term impacts of the event and it will consequently have a new, changed baseline vulnerability. Central in Bohle's approach is the integration of political factors and the importance of power relations for vulnerability. Mukherjee (2004:17) pleads also for the integration of social and political indicators next to economic factors in food security assessments, offering the following set of crucial variables: food availability, ability of the people to access food, institutional sanctions to access that food, individual's freedom to choose food which is culturally acceptable, and existence of secondary food systems, e.g. through gathering and hunting, independent from the food market.

Another aspect is included with Baro/Deubel (2006), arguing for a rights-based approach with respect to vulnerability to food insecurity and famine, as the world community has declared the right to sufficient and nutritious food as human right: "*Everyone has the right to a standard of living adequate for the health and well-being of himself and his family including food, clothing, housing ad medical care and necessary social services, and the right to, in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control* (United Nation 1948)."

The variety of models for vulnerability and food security assessment in the social science may differ in their practical implementation and on the specific focus. Nevertheless, most of them try to embrace the plurality of causal explanations for poverty and vulnerability to food insecurity. These range from lack of political participation over unequality in terms of trade to social marginalization processes. This set of approaches is however criticised (Ribot 2010:53) as ignoring ecological factors of vulnerability. Concepts of ecological vulnerability will be presented in the following.

3.1.2 Ecological vulnerability and hazard research

A second stream of vulnerability assessment incorporates more explicitly natural hazards as triggers for disasters into their models, without excluding the importance of socio-economic and political structures of vulnerable human livelihoods. As the case study is analysed with strong link to global environmental change, central approaches of vulnerability assessment in the natural risk hazard research will be included in the conceptualization of the case study research design.

The Pressure and Release (PAR) model from Wisner and colleagues (2008:49ff.) is based on the assumption that "*[a] disaster occurs when a significant number of vulnerable people experience a hazard and suffer severe damage and/or disruption of their livelihood system in such a way that recovery is unlikely without external aid* (Wisner et. al. 2008:50)." They include two sides of a disaster in their model: The probability and severity of hazard occurrence as well as the baseline vulnerability of human livelihood systems, based on social, economic and political structures. The vulnerability of a group of people depends on the combination of three components that stand in a causal relation to each other: (a) root causes, (b) dynamic pressures and (c) unsafe conditions. *Root causes* are described as "*general processes within a society and the world economy* (Wisner et. al. 2008:52)", consisting of economic, demographic and political developments. These processes reflect power relations within a society and can lead to certain *dynamic pressures*, for example rapid urbanization processes, conflicts or wars and economic crises. These pressures are not inducing vulnerability per se. However, they might finally end in *unsafe conditions*, which form the specific vulnerability of a group of people at a certain point of time. The probability and way of how dynamic pressures lead to unsafe conditions and vulnerability depend on the system's inherited resilience. The concept of resilience comes from ecology and is defined as following: *"Ecosystem resilience is the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a*

different set of processes. A resilient ecosystem can withstand shocks and rebuild itself when necessary (Resilience Alliance[16])*"*. Resilience research is expanded to human livelihood systems with regard to social vulnerability: *"Resilience in social systems has the added capacity of humans to anticipate and plan for the future.* (Resilience Alliance)". Social resilience is based on community based and livelihood inherit resilience, based on different factors: capabilities to balance social stress and conflicts, economic safety nets etc. The World Bank stresses the importance of social learning, hence the adaption of specific livelihood strategies to changing assets (The World Bank 2010:119).

The resilience of a human lievlihoods system (that is a combination of natural and social assets) and thus the peoples' vulnerability is linked to poverty and the process of development itself. A similar argumentation is given by Sen in his entitlement approach. Wisner et. al. (2008:56) state that "*in many cases reducing vulnerability is about dealing with the awkward issue of poverty in society. That is why there needs to be a clear link between disaster preparedness, vulnerability reduction and the process of development itself (the improvement of peoples' livelihoods, welfare and opportunities)"*. The issue is not based on one-dimensional causal linkages, but is embedded in the complex global human-environmental system. Simplistic causal explanations are not sufficient, and case-specific, community-based vulnerability assessment is inevitable (Wisner et. al. 2008:83f.).

The presented PAR model is indicating that the combination of peoples' vulnerability, based on a certain causal chain with the occurrence of a respective type and severity of hazards is leading to a disaster. Turner et. al. (2003a:5074f.) criticise that the PAR model is not sufficiently incorporating concerns of sustainability research in its approach. A further point of criticism is, that it does not provide deeper insight in interactions in the hazard's causal consequences on the human-environmental relations. This, however, is included in the expanded version of the PAR model: The Access model. With the development of the Access model, Wisner and colleagues (2008:87ff.) expand the PAR model: It opens up the *black box* of the mechanisms of disaster unfolding from the moment on when a hazard hits a vulnerable society, or as they put it: "*the access model focuses on the precise detail of what happens at the pressure point between the natural event and longer-term social processes, and, to signify this in visual terms, a magnifying glass is drawn on the PAR model* (2008:87)."

[16] see <http://www.resalliance.org/index.php/resilience> (acc. Nov. 2011).

Central is – with certain similarity to Sen's entitlement approach – "*the amount of 'access' that people have to the capabilities, assets and livelihood opportunities that will enable them (or not) to reduce their vulnerability and avoid disaster* (Wisner et. al. 2008:88)". It hence analyses on a micro-level the occurrence and trajectory of vulnerability and its variations on an individual basis. As the disaster event is here seen as process, it is not a static model, other than the PAR concept.

Basically, the Access model starts with the analysis of the *normal life* of the group of people in focus, be it a family, a household or a community. The normal life is defined through specific access qualifications to resources and income opportunities, creating a specific livelihood. According to Scoones (1998:5) "*[a] livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living".* Each livelihood is embedded in a political and social-economic frame. If a hazard occurs, the livelihood is affected depending on the time and space of the hazard event. According to the specific livelihood components and the peoples' individual choices, the transition from the hazardous event to disaster is unfolding. The hazard can alter capabilities and resource bases. Each unit has system-inherited coping mechanisms that will be applied during the disaster process. Finally, the disaster has – how ever – affected the livelihood in short- or long-term.

The Access model is to some part overlapping with Sen's entitlement approach, incorporating the issue of disaster more holistically and on a broader scale. Although the Access model is deepening the understanding and taking into account different levels (spatial, temporal and in thematic) of vulnerability and the mechanisms of disasters, the ultimate trigger of a disaster is still lying in bio-physical explanations. Bohle (1993:24), however, states that "*[f]actors such as droughts, floods, economic crises or civil wars (…) become causes of a food crisis when they are systematically linked to the long-term structural vulnerability of the society*". Thus a variety of trigger events of a disaster is imaginable, ranging from purely natural events to political, social or economic pressures.

As this work is focussing on vulnerability to global environmental change, the presented models of ecologic vulnerability can provide an appropriate baseline structure for the conceptualization of the vulnerability assessment for the case study. The Access model incorporates parts of the so called Sustainable Livelihoods Approach (SLA) in its explanations. As the SLA is central in sustainability studies of (rural) livelihood, its central elements and principles are being presented in the next chapter.

3.2 The Sustainable Livelihoods Approach

The Sustainable Livelihoods Approach (SLA) evolved in the early 1990ies and has since then been incorporated by several NGOs and governmental bodies of development cooperation (e.g. Oxfam, Care, DFID and UNDP) in project planning, implementation and evaluation processes. Central is the acknowledgement of a holistic understanding of poverty, beyond economy based indicators in development projects (Ashley/Carney 1999:4f.).

The term *livelihood* has been used earlier in this thesis as it is included in different models of vulnerability assessment. As defined above, a livelihood "*comprises the capabilities, assets (…) and activities required for a means of living* (Scoones 1998:5)".

Every livelihood has access to a set of the following five capitals:

- natural capital (land, water, forests, minerals)
- human capital (labour, skills, experience, knowledge)
- social capital (quality of relations among people e.g. family, neighbours)
- financial capital (money in form of savings, loans, credits)
- physical capital (food stocks, livestock, tools and machinery)

These assets can be tangible (tools, livestock, and seed stocks) or non-tangible (experiences, social relations). Based on these capitals the respective group of people[17] is developing a range of livelihood strategies in order to cope with every day's live and external influences. The combination of the set and characteristic of assets with specific livelihood strategies constitute a livelihood system. If the system's internal strategies are able to cope with internal or external stress and shocks and to avoid a negative aftermath in short- or long-term, the livelihood can be called sustainable. The following expanded definition of a sustainable livelihood is drawn from Chambers and Conway (1992): *"[A] livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global level and in the short and long term."*

Based on this theoretical concept of SLA, practical guidelines for project planning and implementation in poverty reduction and rural development came up. Central principles of the practical framework are:

- focus on poverty reduction

[17] The SLA can be applied on different levels: individual, household, village, region or nation (see Scoones 1998:5).

- provision of participation of local communities
- people-centred
- integration of internal as well as external factors of vulnerability

The SLA approach provides a framework for analysis on the one hand and offers a guideline for field work and project implementation on the other. It hence gives theoretical as well as practically oriented input in development research. Bohle (2001) evaluates the SLA after applying it in the field. His general perception of the SLA as framework for analysis is partly negative, as its application does not provide automatically sustainable options for sustainable development. Nevertheless, the SLA provides a tool that is central in development research and project planning for several organizations and institutions and it is furthermore adapted and expanded over time.

De Haan (2000) puts special focus on the dynamic features within livelihoods and thus expands the initially actor based approach by including the multilevel actor-structure reciprocity. This reciprocity is based on the combination of "*opportunities and assets available to a group of people to attain their goals and aspirations, with the interaction with and exposure to a series of favourable or harmful ecological, social, economic and political influences* (de Haan 2000:350)". These connections are visible in feedback loops among livelihoods themselves and between livelihoods and the context in which they are embedded in.

De Haan (2000) further explains another interesting point with regard to sustainable livelihoods: The importance of globalization and localization. Globalization has certain impact on livelihoods, their resources and strategies. The global expansion of means of communication, trade and politics leads to a change in livelihood assets and strategies. They are becoming more and more global, as spatial distances are becoming less important and the structural context is becoming more and more fuzzy and changeable. Livelihood strategies are adapted to these circumstances and are becoming *multi-local*. Globalization processes affect local livelihoods and global homogenization developments are accumulating next to increasing regionalism and locality[18]. De Haan (2000:355) refers to this seemingly uncommon dichotomy as *glocalization*.

These explanations strengthen the need for integrated vulnerability and sustainability assessment, including global structures and processes next to locally adapted approaches, hence a multi-level and multi-dimensional approach.

[18] The simultaneous processes of global homogenisation on the one hand and regional diversification on the other, are incorporated in Scholz's theory of *fragmentising development* (Scholz 2006).

3.3 Plea for an integrated approach in global change research

To include the multi-level human-environmental interdependencies within the system of global change as well as the complexity of vulnerability to its impacts in an applicable model, an integrated approach is inevitable. The relevance of climate change within research on vulnerability and sustainability in the context of global change strengthens the necessity of an integrated approach. Both, risk-hazard research as well as recent entitlement and poverty studies are acknowledging the importance of climate change for vulnerability assessment. Approaches from both scientific disciplines complement each other in the climate change research: Some studies give insight in natural processes and offer predictions of changes in atmosphere, biosphere or hydrosphere. Most commonly used tools of such prediction are different types of scenarios. A scenario can give insight in probabilities of the occurrence of events and thus of risk exposure (Downing 1991:366). Other research focuses more on the impact of climate change on human livelihoods and possibilities of mitigation and adaptation measures.

The task for holistic vulnerability and sustainability assessment in global change studies lies in integrating a variety of aspects in the research design:

- Acknowledging global processes as well as local specific conditions
- Combining natural as well as social science based approaches
- Analysing the internal as well as the external side of vulnerability
- Acknowledging the three dimensions of sustainability

Integrating in this context means developing a concept of multi-causal and multi-scale analysis. It is also necessary to acknowledge the spatial and temporal component of vulnerability: Downing (1991:372) states that "*vulnerability occurs on different spatial and temporal scales*". By accepting this it becomes inevitable to conceptualize a methodological framework that is able to identify time-related changes and processes as well as giving the opportunity and flexibility to implement it on different regions respectively to adapt it to a specific case study. As indicated above, the vulnerability state of a country, region or household depends on its specific local conditions. A model for vulnerability assessment needs to take this into account.

A holistic framework of vulnerability and sustainability analysis needs to consider the two dimensions of global change research, presented above: The spatial and the thematic dimension. Causal linkages in global change processes expand (a) through spatial borders, meaning human livelihoods in one part of the world are influencing not only direct neighbours but also others far away. Furthermore, the linkages expand over

(b) thematic borders: Human and environmental systems are highly interdependent. The assessment of vulnerabilities itself, hence the case study, is limited to a specific spatial scale (region, village, household or individual) and necessarily also to a specific thematic dimension (health, education, infrastructure, land etc.). This specification is inevitable, whereas the effect of global changes differ extremely according to specific spatial and thematic location. However, specific findings can eventually be expanded back to the global and broad level.

With regard to the complex linkages between agriculture, climate change and food security, additional importance of an integrated approach is given, due to following reasons:

- Strong human-environmental interdependencies
- Focal role of land and agriculture
- Reciprocal influence of climate change and human livelihoods

A variety of integrated approaches is existing already. Turner et. al. (2003a, 2003b) provide a framework for integrated vulnerability analysis with strong linkage to sustainability science. The approach is based on central elements of the PAR model and includes the factor of resilience, defined here as "*a system's ability to bounce back to a reference state after a disturbance and the capacity of a system to maintain certain structures and functions despite disturbance* (Turner et. al. 2003a:8075)". In their concept Turner and colleagues plead for a place-based and regionally adapted analysis. They acknowledge the necessity of a holistic and comprehensive vulnerability analysis which includes the totality of the system on the one hand and the limits of data availability and implementation possibilities on the other. None the less, a reduced assessment can still consider the multi-causal and multilevel features of global change. The vulnerability framework of analysis by Turner (2003a) and colleagues consists of three basic components:

- Linkages to the broader human and environmental conditions and processes operating on the coupled system in question
- Perturbations and stressors/stress that emerge from these conditions and processes
- And the coupled human-environment system of concern in which vulnerability resides, including exposure and responses.

They plead for stronger linkages between vulnerability and sustainability analysis in global change sciences in order to provide a holistic basis for (political) decision making.

With regard to vulnerability and sustainability assessment on farm-level, Brklacich (2006) offers a specific, integrated framework for analysis. He states that earlier vulnerability concepts paid less attention to the capacity of people to cope with stress, but more on the identification of exposed vulnerable groups (especially in the risk-hazard research). As "*vulnerability is dynamic and comprehensive and the vulnerability of faming cannot be determined by considering climate change in isolation* (Brklacich 2006:187f.).", different aspects are included in the research framework (figure 7).

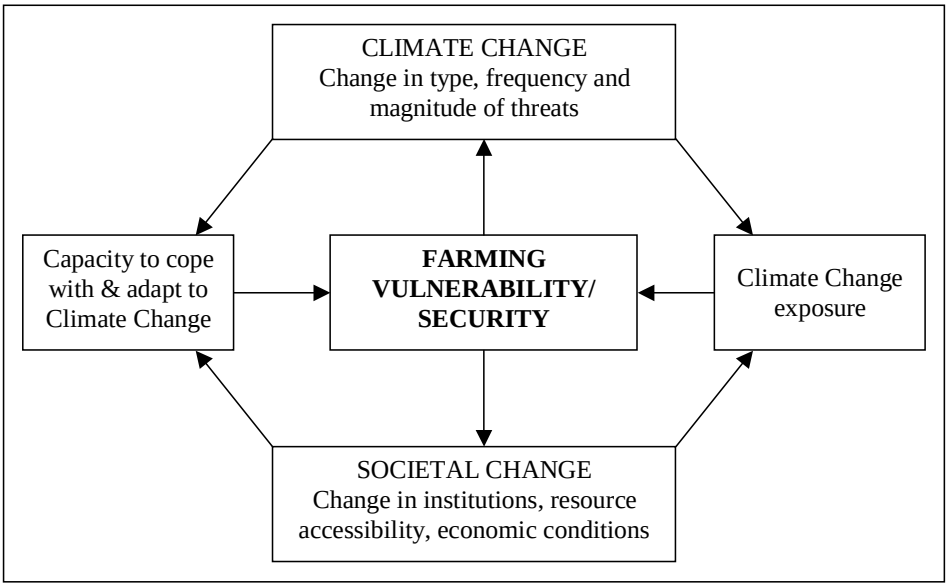

Figure 7: Framework for integrated assessment of vulnerability to climate change on farm-level (Source: Brklacich 2006)

This model for vulnerability analysis integrates ecological as well as social vulnerability, hence internal and external factors in the approach. "*This conceptualization of vulnerability is particularly useful in a climatic change context as it embraces both exposure to environmental stress and human coping capacity* (Brklacich 2006:186)."

With regard to the analysis of the linkages between agriculture, climate change and food security the question arises, how climate change is affecting already existing structures of poverty and vulnerability. Climate change is predicted to strengthen existing inequalities worldwide and already vulnerable regions and sectors are being affected most (see World Bank 2010). Thus, present vulnerability is being aggravated. Central

aspect within this context is the acknowledgement of the idea of "*common but differentiated responsibilities*". Introduced in 1992 on the Earth Summit in Rio it is included in the concept of sustainable development. Later, it was included in the global climate regime with the Kyoto Protocol as well as in the UNFCCC as central principle and frequently discussed at the Conferences of the Parties (COP): The different responsibilities in contributing to global climate change are acknowledged as well as the universality of its impacts and the need for common action. Different approaches are being formulated. The most vulnerable groups and regions to climate change are basically those who contribute the least to anthropogenic increase in greenhouse gas emissions (Parry et. al. 2007). Most affected regions overlap with the group of developing countries and countries that already suffer from hunger and famines. Existing vulnerabilities to global change processes and to food insecurity are being strengthened by climatic changes (see CCAFS/CGIAR 2011).

Consequently, climate change research expands vulnerability research with the aspect of equity and responsibility. Several studies on the ethics of climate change are being published, where these self-inducing inequalities are being discussed and possible solutions are being presented (see Moellendorf 2011, Socolow/English 2011, Adger/Nicholson-Cole 2011). Key argumentations are that as we all humans share the same habitat earth, we have (a) a common responsibility to the mitigation of climate change, hence the emission of GHG gases and (b) a moral duty to balance the effort for necessary adaptation measures among each other. As the principle of *common but differentiated responsibilities* is inducing, the respective (financial or other) effort should be expected according to the country's capacities. This comes into effect, after identifying different vulnerabilities and needs for adaptation and for managing the responsibilities for action (see also chapter 7).

The importance for an integrated scientific perspective with regard to climate change is mentioned by Cannon (2002:349), saying that *"even when a livelihood is inadequate because of poor (or fluctuating) climatic conditions affecting production, it is often important to know why those people are having to live in those places under those conditions: what economic and political factors have led to that particular pattern of access to production resources?"*.

Concluding, an integrated approach to assess vulnerability in the context of global change is inevitable. The complexity of the human-environment interdependencies requires a holistic analysis of causal structures. The interdisciplinary background of

climate change research and vulnerability analysis offers a paved way for developing regionally adapted and case study based models. The following section describes the conceptualization of a specific framework of analysis for the case study of Makrugbeh in Sierra Leone.

3.4 Vulnerability and sustainability assessment of rural poor households in the humid tropics

Case-based and locally adapted assessment is inevitable in global change research as indicated above. The manifold linkages between the broad and global with the specific and local shall be integrated in the research design for the case study, a combined Vulnerability and Sustainability Assessment (VASA) of rural poor households in the humid tropics. The focus of analysis will be vulnerability on farm-level with regard to climate change and food insecurity. The variety of approaches for vulnerability assessment indicates the challenge that it inherits: "*A full vulnerability assessment is no easy task give the complexity of factors, processes, and feedbacks operating within even relatively simple coupled human-environmental system* (Turner et. al. 2003b:8085)." Hence, "*[v]ulnerability analysis must be comprehensive, treating not only the system in question but also many and varied linkages* (Turner et. al. 2003a:8077)." In order to accomplish this task, a threefold integrated research design for the case study is developed: The concept is integrated through (a) combining vulnerability with sustainability assessment, (b) integrating social as well as ecological vulnerability approaches, and (c) including internal as well as external potential causes for risks and stress.

The design of VASA in this thesis is based on the models presented above and consists of four main factors: (a) the baseline vulnerability of one household, consisting of different factors and structures; (b) the exposure to a certain risk of stress or hazard (c) the coping and adaptation capacity of the unit with relation to its resilience and finally, (d) the sustainability of agricultural production as basic feature, influencing the former ones. To clarify the research design and objectives, these four factors of VASA are being discussed in more detail.

(a) Baseline vulnerability and food insecurity: The baseline vulnerability of a human livelihoods system is highly linked to its general standard of living and the status of development and level of poverty occurrence. In general, the higher and more stable the development situation and the higher the standard of living, the lower is the baseline

vulnerability. In the case study analysis the baseline vulnerability of Makrugbeh is described according to the following factors: Ecological constraints, socio-economic situation and challenges and general livelihood strategies. Special focus lies on the status of food insecurity. The analysis of these factors of baseline vulnerability in Makrugbeh is embedded in a broader socio-economic, political and ecological framework.

(b) Risk exposure to climate change: Every place on earth is exposed to certain environmental risk and stress, independent of the system inherent baseline vulnerability. The intensity of this exposure and the specific peculiarity depends on the geographic location. For the case study analysis, the exposure of rural poor households to climate change and the risk of present and future impacts are discussed. Thus, the perception of the farmers of already occurring climatic changes are cross-checked with climate change scenarios and impact assessments for this region.

(c) Coping and adaptation capacity: A system needs a certain coping as well as adaptation capacity in order to balance and cope with stress and hazards. Coping capacity is necessary when a certain stress or risk already occurs: Risks and hazard that occur suddenly and in a short period of time need to be cushioned by the system experiencing it. It can be defined as "*the manner in which the people act within the limits of existing resources and range of expectations to achieve various ends (…). [U]sually it means how it is done in unusual, abnormal and adverse situations* (Wisner et. al. 2008:112)". Concerning creeping, slow processes of stress and change, adaptation capacity is required, meaning long-term changes and adaptation to stress of the system as a whole. The stronger the system's coping and adaptation capacity, the higher is its resilience. Different coping and adaptation strategies of rural households are imaginable with regard to climate change and food security (see Wisner et. al. 2008:115ff.): Preventive strategies, impact-minimising strategies, food stores, diversification of production and income sources, developing social support networks and safety nets as well as post-event coping strategies. In the case study analysis the respective capacities and strategies for Makrugbeh are discussed.

(d) Sustainability: This fourth factor, the sustainability on farm-level, is not seen as additional feature on the same level as the former three, but is interfering with those to some extent. It is assumed in this work that the more sustainable a livelihood, the lower is its vulnerability in general and in specific to climate change. There is a correlation of the baseline vulnerability and the coping and adaptation capacity of a household with its

sustainability: The higher the sustainability of a system, the higher is its coping and adaptation capacities and the lower its baseline vulnerability. However, on has to keep in mind that other, external factors do have an impact on these components too, such as political and socio-economic structures. In the writer's perception, the state of sustainability of a farming system has no direct influence on the component of risk exposure[19].

Summing up, the more sustainable a system, the higher is its coping and adaptation capacity and hence its resilience. In the case of rural poor households it means, that a farming system that practices sustainable farming, adapted to the specific local conditions of soil, crops, climate and socio-economy, is more likely able to balance and cope with risks and environmental stress, such as climatic changes. Thus, sustainable agriculture has the opportunity to decrease the baseline vulnerability as well as to strengthen the coping and adaptation capacity of rural households. Small scale sustainable farming has no impact on the risk exposure, whereas global conversion to organic farming could contribute to mitigation of climate change and thus hypothetically reduce the occurrence or intensity of certain risk and stressors. The general concept of VASA (figure 8) for the case study of Makrugbeh is being expanded in the following with the specific research design and the conducted methodology.

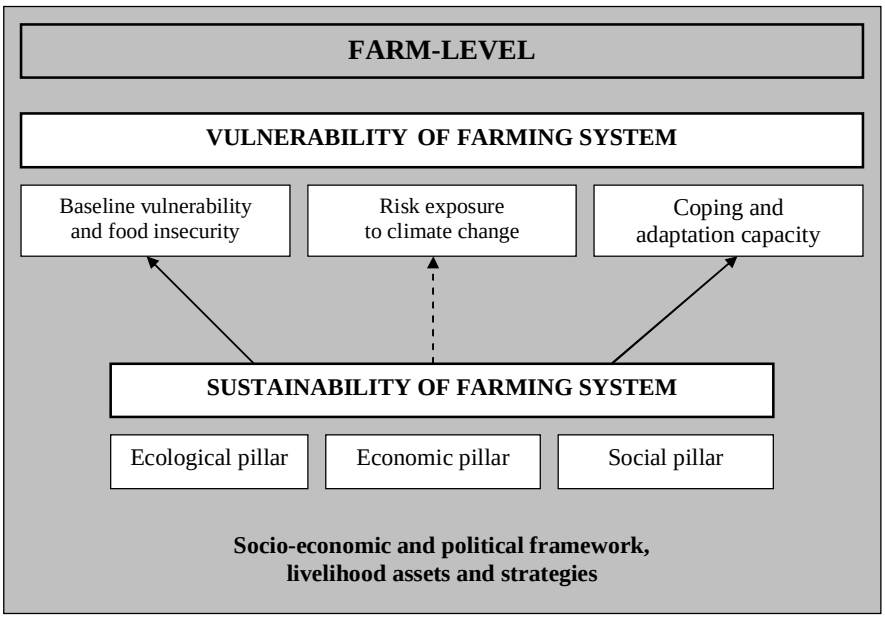

Figure 8: VASA model for assessment on farm-level.

[19] It can be argued, that the increase in sustainability on farm-level might mitigate global change processes and thus reduce the occurrence of certain risks and hazards. That would lead to a decrease in risk exposure. However, the writer assumes that a significant impact on the occurrence or intensity of risks and hazards is just possible, if the sustainability of a critical mass of farming systems increase over a certain period of time. As this is rather hypothetical, the expected linkage is being left out in the case study analysis.

4. Research design and methodology

4.1 Aims and objectives

Agriculture plays a focal role within the system of human-environmental interactions of global change. Rural poor households are especially vulnerable to food insecurity and global environmental change because of a coupled system of global human-environmental interdependencies. Analysis of single case studies with respect to individual local conditions, challenges and potentials contribute to a better understanding of the nature and transformation of vulnerability, its causal factors and possible improvement measures. "*Place-based approaches do not preclude the ability to develop general characterizations of the vulnerability of coupled systems. On the contrary, the use of place-based approaches makes obvious the need to find methods to operationalize vulnerability analysis that are useful for the specificity of place and for building general concepts from them* (Turner et. al. 2003a:8076)." The case study analysis of Makrugbeh village, located in Northern Sierra Leone in Western Africa, provides space-based results for insights in global change research.

First, the research design and the methodological approach are being presented. The selection of methods and the way how they are being conducted and evaluated is central for case study analyses. "*If we do not ask the right people the right sort of questions in the right sort of way we will not be able to draw general conclusions no matter how good our data looks. (…) The leap from correlation to causation should be made with great caution* (Overton/Diermen 2009:50)." It depends on the researcher's perceptions and on the specific aims and objectives of the analysis, which methods are being implemented.

The aims and objectives of the case study of Makrugbeh are:

- Indicating the crucial role of agriculture within global change processes on local scale
- Describing one of the most vulnerable regions with regard to climate change and food insecurity
- Showing the correlation of vulnerability with sustainability on farm level
- Giving insight in specific challenges and potentials for sustainable rural development on farm and household level

The case is being analysed with application of the VASA model, introduced in the last chapter, including the baseline vulnerability, the risk exposure, the coping and adaptation capacities as well as the state of sustainability on farm level.

The main level of analysis is the rural household, respectively the single farm. Although the methods conducted in the field offer insight in the structure of the village as a whole, the focus lies on the assessment of vulnerability and sustainability of individual rural households. In the concluding chapter the case based information are projected back to a broader spatial level.

The use of household as analytical category has several advantages, but it also contains challenges with respect to data collection and especially to interpreting the data appropriately. Additionally, as Wisner et. al. (2008:96) put it: "*There are cases where it is difficult to distinguish households at all*". Nevertheless, the main focus of research will lay on the household and farm level. In a village like Makrugbeh this can be seen as almost synonymously as one household, consisting mostly of members related through kinship, have a specific area of farmland that they work together. Kaspar/Kollmair (2006) give an overview of the key elements of the decades-long discussions about different ways of defining household as analytical category and to use it for field research. Earlier approaches are subsumed as neo-classical household models where the household is seen as closed system of production and consumption (Kaspar/Kollmair 2006:106ff.). These concepts have been criticised repeatedly for disregarding internal differences of household systems as well as internal power relations and social structures. So called bargaining models concentrate more on the interior of the household, analysing power relations, underlying values and their changes over time. Within this stream, feminists focus on the role of women, especially with respect to structures of power and influence. Finally, Kaspar/Kollmair argue for seeing households as open social systems where power relations and kinship bonds can supersede its borders significantly, as they put it: *"[H]ouseholds should be perceived as consisting of individuals who do interact with members of other households. (…) [L]ooking at households, it is not only interactions of household members beyond the household that should be of interest, but also the cultural, social, economic and political and spatial framework in which the household is embedded* (2006:116 f.)."

This conceptualisation of household as analytical category seems to come very close to the definition of livelihood within the Sustainable Livelihoods Approach (SLA) (as presented in chapter 3.2). As this case study does not claim to offer a complete

sustainable livelihoods appraisal, the writer will continue to use the term *household* for the analysis and further explanations. Nevertheless, the borders of household and livelihood do indeed overlap, what makes a specific classification difficult, and parts of the analysis of this case study can for sure give insight in the state of the livelihood of Makrugbeh and its population.

For this work *household* shall be used synonymously to *farm*, as Makrugbeh village consists of different households, defined as a group of mostly related people sharing food and shelter and, who all – according to their age, gender and fitness – contribute to common farming activities. These farming activities and the agricultural products are the only source of income for the household: income in form of natural commodities like food, and in form of money through trade. The household is seen as open system with interdependencies with the surrounding social, political, economic and natural framework it is embedded in.

The methods used for this case study are composite of quantitative as well as qualitative methods, combining participatory and non-participatory approaches. Within the category of quantitative research a structured interview has been conducted, the qualitative methods come from the stream of Participatory Rural Appraisal (PRA): focus group discussion, seasonal calendar and pair wise ranking. Finally, more insight is given through the implementation of RISE (Response-Inducing Sustainability Evaluation). The case study is implemented by triangulation of these different methods in the field (method triangulation) as well as triangulation of the collected data with data from secondary sources afterwards (data triangulation). The following section introduces the tool of triangulation and its application area.

4.2 Triangulation

4.2.1 General introduction

Some research areas can not be allocated exactly to one specific scientific stream: Several scientific disciplines do overlap partly in thematic and methodical dimension with one another. Geographic research is often based on analysis of human-environment linkages and is thus balancing on the border between natural and social science. For respective holistic understanding and appropriate interpretation, a broad methodological approach is recommendable. In such cases, the possibility of triangulation offers an adequate way of integrating different approaches into field work and analysis for the researcher.

According to Flick (2008:10) triangulation implies taking up different perspectives on the research object throughout the research study. These changes in perspective can be accomplished by implementing different methods or by underlying different theoretical approaches for the analysis. Another way of triangulation is the combination of different types of primary and secondary data. In this respective case study the focus lies on method triangulation, which will be viewed in more detail.

Method triangulation leads to one of the three possible outcomes of the research results (Flick 2011:35): The findings from different methods are converging, hence their results match with each other; The data are complementary, meaning different methods provide different information; Or the results are diverging, thus the findings from different methods do have opposing outcomes. According to the research objectives, the respective interaction of results shall be taken into account for further interpretation.

The plurality of methods in geography and neighbouring disciplines offers a broad variety of possibilities for combination and triangulation. Imaginable distinctive features are: The underlying research principles, the spatial, temporal or thematic scope and scale, the differences between quantitative and qualitative methods, the level and way of participation possibilities and others.

Triangulation of different scientific methods has following general advantages (see Flick 2011, 2008): Data, gained from one source can be cross-checked by using additional, complementary methods. Methodological disadvantages and limits of one method can partly be balanced by others. Some methods of data collections imply bias and normativity (the final results depend to a certain degree on the individual performance and objectives of the researcher). In general, it is highly recommendable - if not even necessary - to cross-check findings from field research. Triangulation offers almost never-ending options in combining methods in order to gain a broad database for analysis.

However, there are also disadvantages respectively problems and challenges with regard to method triangulation (see Flick 2011, 2008): Obviously, triangulation of a set of methods is much more time consuming than the application of just one single method. More time is needed for method application in the field. Also the processing of the gathered information and the data analysis needs extra time, if it is done with different methods, which require different approaches of processing. Furthermore, the researcher must have good knowledge of all methods he/she wants to apply in order to work appropriately in the field.

Nevertheless, method triangulation puts the research on a broader and more reliable data basis and thus makes the whole analysis more trustworthy and meaningful.

Depending on the respective method triangulation, more specific advantages and disadvantages can be identified. By comparing "conventional" quantitative questionnaire survey with participatory methods, Mukherjee (1995:33ff.) points out major differences within four categories: The paradigmatic basis, governing principles, the role of objectives, and data evaluation. The triangulation of quantitative questionnaire with qualitative participatory methods is highly supported by Mukherjee (1995). His evaluations are based on broad field experiences and case studies, mainly implemented in India and neighbouring countries. He describes several advantages of this kind of triangulation (1995:95ff.), among them *appropriate adoption*: Structured questionnaires can have the disadvantage that they create a barrier between the facilitator and the interviewee. They are often written in a language other than the mother tongue of the participant, contain complex information and they might create an atmosphere where the respondent is biased in his answers. The combination with qualitative and participatory methods could help to overcome gaps of language, predetermined content and focus. *Questions to anticipate*: As the questions, asked in a conventional interview, are predetermined by the researcher, they are completely based on her/his knowledge and perception. This one-dimensionality in perspective can be overcome if other actors are included in the field survey design and if there is open space for input from others throughout the implementation. *Group interaction*: Conventional questionnaires are designed to gather individual information from one by one participant. Group power relations and interactions are left out of this kind of setting. Participatory methods however are often designed for a group of participants. The arising group interactions can create an innovative atmosphere for discussion and exchange and thus provide further important information. For the case study of Makrugbeh a method triangulation was implemented out of different reasons:

- A single scientific perspective is not able to embrace the variety of structures constituting a rural livelihood appropriately.
- As the analysis of households in a rural poor setting is located in the complex system of human-environmental interdependencies, it requires an integrated and interdisciplinary approach.
- Furthermore, the application of just one type of methods does not cover an analysis of vulnerability and sustainability holistically.

Especially with respect to analysis of food insecurity and vulnerability to hunger, integration of different methodological approaches is favourable. As Baro/Deubel (2006:526) state: "*by combining quantitative and qualitative indicators, food security studies have thus increased in accuracy and validity*".

The presented case study is based on the triangulation of three different methods of rural appraisal as well as on the triangulation of primary with secondary data. The secondary data, mainly gathered from governmental and civil society reports and statements complement the field work findings.

4.2.2 Method triangulation for the case study Makrugbeh

For the conduction of the VASA model on rural poor households in Makrubgeh, a threefold method triangulation was implemented. The findings are based on the combination of (a) qualitative and quantitative methods, (b) participatory and non-participatory methods, and (c) on methods focussing on vulnerability and sustainability assessment on farm-level. Each category of method triangulation is presented in more detail in the following.

(a) Triangulation of quantitative and qualitative methods

During the last decades, theories and concepts of development changed significantly (see Fischer et. al. 2008). The so called *"Ende der Dritten Welt und das Scheitern der großen Theorien"* ("The end of the third world and the failure of the big theories", translation by the writer) stated by Menzel (1992) marked a paradigm shift in the circle of development research[20]. A variety of small-scale concepts and theories has been developed, putting more and more emphasis on regional specific conditions, on social and political factors of development and on the inclusion of civil society in the process of development planning and implementation. The changes are listed by Chambers as "*from top-down to bottom-up, from centralized standardization to local diversity, and from blueprint to learning process* (1994a:953)". A group of scientists oppose and even refuse the complete concept of development research and cooperation existing so far. Menzel (2001) deconstructs the category of developing countries in general, and hence enfeebles even small-scale development approaches. Next to these anti-development approaches, others plead for post-development, and thus for handing the responsibility

[20] In this context the so called "big theories" embrace modernization theories on the one hand and the opposing *dependencia* theories on the other. Although the respective underlying understandings of (under-) development differ completely, they had in common to claim global applicability in any context. This claim basically led to their "failure" in a reality of structural differences (see Nuscheler 2005).

as well as the power for change from international organizations over to the local community (see Ziai 2006).

Connected to changing theoretical approaches and scientific schools the design of methodology underwent similar alteration and modes. With time, more and more qualitative methods were used in the field. According to Brockington/Sullivan (2009:57) the three basic components of qualitative research are: Interacting with the affected people, collecting data in natural settings and, working inductively, hence rather generating theories instead of testing them in the field. Qualitative data is often criticised as being not representative and not able to provide useful information, but as Brockington/Sullivan put it, "*treated properly they are as strong, relevant and interesting as data that are numerical or otherwise easily categorised* (2009:71)".

Quantitative methods on the other hand are characterized as "*objective, representative and most important, specified in number* (Overton/Diermen 2009:38)." In distinction to qualitative techniques they provide assumedly independent facts and data, irrespective from the researcher. Underlying concept is the generation of information about selected specific cases and application of these to a broader scale or to other cases with similar characteristics. According to Overton/Diermen (2009) the outstanding strength of quantitative methods lies within the possibility of verifying and replicating them: The basis of objective and neutral assumption as well as the transparent and clear techniques let outsiders understand and reconstruct the process of analysis. Application of the same methods by different persons or at a different point of time should come up with basically the same results. However, quantitative data are always connected strongly to the individual perception of the researcher and they are often claimed as being biased and normative. By looking at the respective features of quantitative and qualitative methods, it is self-evident that triangulation is recommendable in order to balance the respective disadvantages and limits as well as to embrace the respective advantages.

(b) Triangulation of participatory and non-participatory methods

Within circles of qualitative research the concept of participation gained more and more importance, beginning basically in the early 1990ies. On the one hand, several organizations in the sector of development cooperation tried to open their project cycles more for civil society, especially for the affected people itself (Bliss 2009, Mukherjee 1995). On the other hand parts of the research community focussed increasingly on the inclusion of locals – scientists and politicians as well as members of civil society – in their scientific work. A new set of participatory methods was developed and used in the

field. "*The more important emphasis on participation resulted from a disenchantment with information-collection methods which gave all key responsibilities to outsiders rather than community members or the community development workers who work with them* (Theis/Grady 1991:1)." Especially in vulnerability and sustainability assessments, participation in research and implementation was promoted. Looking at the food security research, Baro/Deubel (2006:526) stress, how participation of individuals and the integration of subjective perceptions of food insecurity among local populations is improving understanding of vulnerabilities and structural causes of food insecurity and hunger.

Case studies show how vulnerability to food insecurity and related fields of research can be appropriately analysed in using participatory methods. Mukherjee (2004) describes different study regions, mainly in India and South-East Asia, where the integration of the local community was secured by adopting PRA methods. Hence, participatory methods complement non-participatory tools. Their triangulation reduces the risk of bias and normativity and offers a more holistic view through different perspectives, especially by including the people that are in focus of the research.

(c) Triangulation of methods for vulnerability and sustainability assessment

The third feature of method triangulation for the case study is based on differences in the research focus of methods. As the research questions open a broad field of analysis, it is recommendable to investigate from different perspectives. Some methods are conceptualised specifically in order to give insight in structures of vulnerability, depending on the underlying definition of the term. Others provide information on sustainability on farm level. Sustainability is highly related to the vulnerability of a system, especially with regard to farming systems. The sustainability of farming activities of a rural household can give insight in the conditions of baseline vulnerability as well as in coping and adaptation capacities, especially with regard to food insecurity and climate change (see chapter 3.4).

Approaches and methods for vulnerability assessment are manifold, as indicated in chapter 3, depending on the case specific conceptualization. Sustainability on farm-level can also be analysed with a variety of methods (see Doluschitz et. al. 2009 and Zapf et. al. 2009). The approaches differ in the choice of indicators for the three dimensions of sustainability on farm-level as well as on the design of how to assess these indicators in the field. Zapf et. al. (2009:405ff.) strengthen the importance of embedding locally gathered data in the respective regional framework. It is necessary to cross-check with

regional specific soil and fertility information, the socio-economic conditions and others. Depending on the research question and objectives, an adequate method shall be chosen[21].

Sustainability analysis complements methods that focus specifically on baseline vulnerability, risk exposure and coping as well as adaptation capacity in several ways: By assessing all three pillars of sustainability, the ecological dimension is included in more detail, that would be marginalized eventually with purely social-science based vulnerability assessments. Furthermore, sustainability assessments of farming activities are often implemented on farm-level, what helps to identify specific and individual challenges and potentials. However, this makes it difficult to generalize the data on broader spatial scale.

Figure 9 gives an overview of the set of methods conducted in Makrugbeh according to their underlying research paradigm, the inclusion of local community and their main focus. The distinction and attribution is based on the specific case study and does not claim being representative.

	Research paradigm		**Inclusion of local Population**		**Main focus**	
	Quantitative	Qualitative	Participatory	Non-participatory	Vulnerability	Sustainability
Standardized questionnaire	**x**			**x**	**x**	**(x)**
PRA methods		**x**	**x**		**x**	
RISE	**x**	**(x)**	**(x)**	**x**		**x**

Figure 9: Triangulation scheme of conducted methods for the case study.

The basic data of household structure and farming activities is gathered by a quantitative questionnaire. More detailed, complementary information of the rural livelihoods is gained through implementation of different methods of Participatory Rural Appraisal. Within this context a focus group discussion, a seasonal calendar and a pair wise ranking have been implemented in Makrugbeh. Finally, a complex and time-intensive sustainability analysis of selected farming households was conducted, using RISE (Response-Inducing Sustainability Evaluation), a tool developed by the Swiss College of Agriculture (SHL). In the following the three different approaches and tools are presented in general as well as their specific implementation in Makrugbeh.

[21] For more detail and evaluation of different concepts of sustainability analysis on farm-level, see Zapf et. al. (2009).

4.3. Description of conducted methods

4.3.1 The standardized questionnaire

The standardized questionnaire is a common quantitative method of data collection. Other tools of quantitative data collection are: Observations and structured interviewing (Overton/Diermen 2009). This method is characterized by a specific set of questions, presented orally or in written form to the interviewee. There are different possibilities of posing questions in a questionnaire: They can be put open or closed, with one or with more choices, as rankings or as preference list.

One advantage of standardized questionnaire is that the data can be compared due to the underlying similarity of the context it is conducted in one case: The conditions of questioning are similar for all participants and more importantly, exactly the same questions are asked in consistent order. Furthermore, the results can be processed relatively easily and provide a rather clear database for reliable statements, given that its significance is acceptable.

The standardized questionnaire used for the case study Makrugbeh (see Appendix II) consists of 88 questions, put into two blocks: Household related question and farm related questions. It starts in accordance with the recommendation by Overton/Diermen "*with the basic and least intrusive questions and progress to the more complex and sensitive questions* (2009:39)." In the section about household structure and size relevant topics are the number, gender and age of household members. With respect to farming activities questions are asked about farm size and components, the agronomic practice of shifting cultivations, specific cropping systems and main field crops as well as basics of animal husbandry, where necessary

The questionnaires were conducted orally in the village of Makrugbeh. The interview language was English, whereas participants unable to speak English were supported by other village members who translated into Krio or Temne. In Makrugbeh 15 farmers were interviewed[22] during a period of two days. The participants were chosen based on convenience sampling[23], that occurs "*when people are chosen because they are conveniently available* (Overton/Diermen 2009:43)".

The writer is aware of the fact that the relatively small number of 15 samples as well as the coincidental way of choosing the participants limits the representativeness of the

[22] The respective farmers, participating in the different methods are listed in Appendix I.

[23] Other options are snowball sampling, purposeful sampling or quota sampling, each having different advantages, depending on the specific case (Overton/Diermen 2009:43f.).

data. They do not provide information with an adequate statistical significance. However, the households within Makrugbeh are rather homogeneous in structure and farming activities, as observed during the field visits and repeatedly during the focus group discussion. Given "*the larger the sample and the more homogeneous the population the smaller the standard error* (Overton/Diermen 2009:44)", the trade-offs in significance and representativeness due to small number of cases and convenient selection of samples might be excused up to a certain degree. Furthermore, it is a sufficient and appropriate way of sample selection for the objectives of this specific case study. The data collected through the standardized questionnaire shall not provide the major basis for analysis. It shall be used complementary to the findings through other methods and through secondary data sources.

The conduction of a standardized questionnaire can be identified as a completely non-participatory method. The interviewees have no influence on type, content and order of questions and on how the interview will be designed and implemented. They can indeed choose individually if and how to answer the questions, but in general they have no impact on the research design. Thus, the researcher itself provides the basics for the analysis and the choice lies completely in his own perception. These disadvantages of quantitative methods can be overcome partly by triangulation with other, more qualitative and participatory methods.

4.3.2 Participatory Rural Appraisal

Within the paradigm shift in the development research and the increasing acceptance and use of qualitative methods, the methodological toolkit of the so called Participatory Rural Appraisal (PRA) was introduced.

"*Participatory Rural Appraisal (PRA) is a methodology which helps in interacting with local communities, understanding them and learning from them. It helps in the process of involvement with local communities for indigenous knowledge-building exercises. It is a way of learning from and with community members to investigate, analyze and evaluate constraints and opportunities and make informed and timely decisions regarding development projects* (Mukherjee 1995:27)." According to Chambers (1994a: 961ff.) practical applications of PRA methods for participatory appraisal, planning, implementation, monitoring and evaluation are mainly found in the sectors of natural resources management, agriculture, poverty and social programs, as well as in health an food security. A long list of different tools and methods are described in several manuals from research and development organizations (see CARE 2002, Gonsalves et.

al. 2005a, 2005b, 2005c, Salas et. al. 2003, Theis/Grady 1991), for example: Key informant interview, group discussions, participatory mapping and modelling, transect walk, daily time use analysis, seasonal calendar, matrix scores and rakings and many more.

For the case study presented in this work, three different tools of the PRA basket were used for data collection in the field and will be described in more detail in the following: (a) Focus group discussion, (b) seasonal calendar and (c) pair wise ranking.

(a) A focus group discussion is a specific type of semi-structured interviewing[24], defined as "*a form of guided interviewing where only some of the questions are predetermined. PRA interviews do not use a formal questionnaire but at most a checklist of questions as a flexible guide* (Theis/Grady 1991:52)". The advantage of semi-structured interviewing is, that the interviewees or participants are relatively open to what and how they talk and discuss about a certain topic. The facilitator creates an atmosphere where every participant is invited to talk freely and give own ideas and thematic input. The facilitator and the interviewees are invited to come up with new questions during the discussions. Hence, the researcher provides a set of keywords and questions, whereas the process of dialogue and discussions is left open. In case of focus group discussions, a relatively small group of participants discuss a specific topic in more detail. Theis/Grady (1991:53) describe it as "[a] *small group of people (six to twelve) who are knowledgeable or who are interested in the topic(s) are invited to participate in the focus group discussion. A facilitator is chosen to ensure that the discussion does not diverge too far from the original topic and that no participant dominates the discussion*".

In Makrugbeh, the focus group discussion took place on three days. Each day the duration of the session was one to two hours. The seven participants were interested representatives from the village, amongst them the town chairlady, the town secretary and the section chief. The following key issues were discussed during two sessions: General information on the village setting and its functions for the environment; The socio-economic situation in the village; Farming practices and main agricultural products; And general challenges for the rural livelihoods, among them occurring climatic changes.

(b) The creation of a seasonal calendar can provide more detailed information on how the type of work and the workload on farm-level differ throughout the year.

[24] Other types of semi-structured interviewing are: Individual interview, key informant interview and group interview (Theis/Grady 1991:52).

According to the research interest different issues can be included in the seasonal calendar, such as climatic information, crop sequences, occurrence of crop pests and diseases, labour demand, price developments and social events. A seasonal calendar of a rural livelihood can indicate the different seasons of agronomic activity, like the main planting and harvesting seasons, critical months for crop pests and diseases and even times of food shortages and high work demand.

To create a seasonal calendar the facilitator provides the empty form for "*a 12-month or 18-month calendar as appropriate. It need not start in January and should reflect the indigenous seasonal categories* (Theis/Grady 1991:92)". To fill in the empty graph and to get the required information a series of questions has to be asked about the differences of type and load of work throughout the year. Some data might be gained from other sources, for example information on rainfall and solar radiation from meteorological departments. These secondary sources could also be used to cross-check the information gathered in the field. According to the research question specific information on agronomic practice can be drawn from the seasonal calendar and be presented in diagrams and time-line graphs.

For the case study of Makrugbeh, a seasonal calendar was created with seven interested farmers. The calendar contains information on climatic seasons, crop sequences of main agricultural products, work load changes and periods of food shortages (see Appendix II).

(c) If concentration on a specific topic is intended and a ranking of different options is desired, the researcher can conduct a pair wise ranking matrix. This tool can be used in order to compare different options of a specific problem or issue with each other. Finally, it provides a ranking list of the analysed possibilities.

According to Theis/Grady (1991:65ff.), following steps are of basic necessity for a pair wise ranking:

1. Choose a set of problems or preferences
2. Choose six or less of the most important items or options
3. Let the participant(s) compare and rank two of them and fill the result in a pair wise ranking matrix
4. Repeat this step with all items chosen, so that each option is being compared to all others
5. Calculate the ranks of the items
6. Cross-check the findings with the interviewee(s)

In Makrugbeh, a pair wise ranking was conducted to analyse in more detail the challenges for agricultural activities in this specific village setting. The group of seven participants was composed of interested farmers and it took roughly one hour to complete and cross-check the matrix and findings. The participating farmers were asked to name challenges and problems they personally face as farmers. They came up with the following list of items: lack of seeds, lack of fertilizer, occurrence of pests, changing climatic conditions and lack of tools (see Appendix III).

4.3.3 Sustainability Analysis RISE

The sustainability on farm level is analysed as significant complementary component of vulnerability assessment of rural poor households. There is a variety of tools for analysing sustainability on farm-level, but not all are adapted to rural poor settings in the tropics. For the case study of Makrugbeh, the computer-based tool RISE (Response-Inducing Sustainability Evaluation) was chosen. This method[25] was developed by a research team at the Swiss College of Agriculture (SHL). RISE has been conducted successfully in different regions throughout the world, amongst them in the following African countries: Ethiopia, Kenya and Ivory Coast.

The objective of RISE is to improve measurability and implementation of sustainability on farm-level. Central concept is to analyse individual sustainability indicators and identify farm-specific challenges and potentials. Hence, RISE is not a simple pass-or-fail sustainability test, but provides indictor-based insight in the grade of sustainability on farm-level.

"*The Response-Inducing Sustainability Evaluation (RISE), developed at the Swiss College of Agriculture (SHL), (…) [is] providing a farmer- and measure-oriented sustainability evaluation method. The assessment covers agricultural production on a farm within one year and starts with the collection of comprehensive information on ecological, economic and social aspects through a questionnaire-based interview with the farmer* (Grenz et. al. 2009:5)."

Usually, the following steps are included in the RISE-analysis (see Grenz et. al. 2011:10ff.):

- Collection of national and regional data
- Selection of farms

[25] For the case study RISE 2.0, a version, revised in 2011 was used. Main differences to the initial version lie within the number and selection of indicators and parameters. Furthermore, in the first approach, the category of *driving factors* has been included in the calculations (see Grenz et. al. 2009).

- Farm visits and interviews
- Calculation of indicators and parameters
- Feedback workshop with the farmer

A standardized questionnaire, covering social, economic as well as ecological sustainability indicators is conducted on farm. The respondent should be the head of the farm, but also family members and employees can contribute. While conducting the interview it is recommended to visit farm buildings and sites in order to cross-check the responses and information given by the farmer. The gathered information and data is then input into the computer programme. In the handbook for the use of RISE the authors describe its function as following: *"A computer model uses this information to calculate* [51] *sustainability parameters, condensed into* [ten] *indicators. Indicator scores are displayed as a polygon showing farm sustainability at a glance. At parameter level, results are presented in tabular form, which allows for a differentiated appraisal and pinpointing of trade-offs in the concluding feedback discussion* (Grenz et. al. 2009:5)."

The respective indicators and its parameters are listed in figure 10. They embrace the economic, ecological and social pillars of sustainability on farm-level. The value of each indicator can range between 0 (problematic status of sustainability) and 100 (best status with regard to sustainability), based on the performances of the respective parameters.

Pillar of Sustainability	Indicator	Parameter
Ecology	**Energy & climate**	• Energy management • Energy intensity in agricultural production • Proportion of sustainably produced renewable energy • Greenhouse gas emissions
	Water use	• Water management • Water supply • Water use intensity • Risks for water quality
	Soil use	• Soil management • Crop productivity • Humus provision • Soil reaction • Soil pollution • Soil erosion • Soil compaction
	Plant protection & biodiversity	• Management of plant protection and biodiversity • Ecological priority zones • Intensity of production • Landscape quality • Diversity in agricultural production

	Cycles of matter	• Nitrogen balance • Phosphorus balance • N- and P- self-supply • Ammonia emissions • Waste management
	Animal husbandry	• Herd management • Productivity of animal husbandry • Possibility of species-appropriate behaviour • Living conditions • Animal health
Economy	**Economic viability**	• Liquidity reserves • Dept factor • Economic vulnerability • Household existence security • Cash flow performance • Consumption of capital service limits
	Farm management	• Farm strategy and planning • Supply and yield stability • Planning instruments and documentation • Quality management • Farm cooperation
Social	**Working conditions**	• Personnel management • Working times • Work security • Wage and income level
	Quality of life	• Work and education • Financial situation • Social relations • Personal freedom and values • Health • Other areas

Figure 10: Indicators and parameters of RISE 2.0 (Source: Grenz et. al. 2011).

In calculating the indicators and parameters and their specific occurrence, "*RISE administers farm related data, regional data and reference data.*" Farm data is collected individually through the interview and site-visit on farm level, whereas regional and reference data has to be gathered from secondary sources. They include information on climate, geology and policies concerning sustainable farming in the region. The final data are presented in form of sustainability-polygons for the feedback discussion on the farm and for further analysis.

The computer-based tool of sustainability analysis RISE differs strongly from the other methods used for this case study. It is neither pure gathering of quantitative data like the standardized questionnaire, nor is it a completely qualitative method. It includes quantitative as well as qualitative information, although the qualitative information is being "quantified" for the calculations. It is not a method that can be included in the basket of Participatory Rural Appraisal either. The questionnaire itself is standardized and based on a set of indicators and parameters for the calculation of the respective

degrees of sustainability. But, it has certain participative features, because the farmer is very much included in the analysis: RISE offers space for the farmer to explain and strengthen issues that are important for him during the interview and the final feedback workshop has a participative structure. It gives the farmer the opportunity to evaluate the findings in his or her own opinion and to come up with individual perceptions of challenges and potentials.

RISE was used in order to specify the situation of farmers in Makrugbeh with respect to sustainability and sustainable farming. It offers the possibility of deeper insight in ecological, economic and social parameters and indicators of sustainability on farm level. Thus, it can indicate specific challenges and deficiencies and hence prioritize future activities. Three farmers participated in the RISE-analysis. The aim is not to provide regionally generalized information, but to give examples of the degree of sustainability and weaknesses and strengths of rural households in Makrugbeh with regard to their vulnerability. Nevertheless, given the high degree of homogeneity among the households, limited conclusion can be drawn for the village as a whole.

Method		**Objective**	**Number of participants**
Structured questionnaire		Collection of data for more general information on household and farm structures	15
Participatory Rural Appraisal (PRA)	Focus group discussion	Generation of general information on village settings, livelihood situation and agronomic practice.	7
	Seasonal calendar	Allocation of more specific information on farming activities and socio-economic situation.	7
	Pair wise ranking	Specific investigation of challenges and problems of farming activities.	7
Response-Inducing Sustainability Evaluation (RISE)		Analysis of individual ecological, economic and social sustainability on farm level.	3

Figure 11: Overview of the methods conducted in Makrugbeh.

Figure 11 gives a final overview of the methods, conducted in Makrugbeh and indicates the differences between the tools according to their scope of objectives and number of participants. Other sources of (secondary) data are reports from governmental bodies and international organizations. Throughout the analysis the secondary data are used complementary to the ones collected in the field. They build a framework of general information for Sierra Leone and the region of Makrugbeh, in which the empirical data are embedded in (data triangulation).

5. Case study: Vulnerability and sustainability of rural poor households in Makrubgeh, Northern Sierra Leone

As indicated above, rural poor households in the tropics are especially vulnerable to global change, especially to climate change and food insecurity. They are affected by a rather high baseline vulnerability to food insecurity and poverty as well as the exposure to higher risks for example concerning negative effects of climate change. Additionally, the adaptation and coping capacity of poor rural households is low, as is the resilience of some agro-eco-systems in the (humid) tropics. The status of sustainability of a farming system correlates partly with its vulnerability. These human-environmental linkages are being analysed for one specific case:

In Makrugbeh, a village in the North of Sierra Leone in Western Africa, the presented bundle of methods for Vulnerability and Sustainability Assessment (VASA) has been conducted over a period of four months between June and September 2011. As introduction to the specific case, a short overview of the eco-zone of the humid tropics with summer rains and to the socio-economic and political situation in Sierra Leone is given. Finally, the results and findings of the field research are presented and discussed.

5.1 Description of the case study area

5.1.1 Land-use in the eco-zone of the humid tropics

The eco-zone of the humid tropics ranges from the evergreen rainforests around the equator to the dry savannahs and desert regions of the arid (sub) tropics. In this context, a closer look to humid tropics with summer rains (*sommerfeuchte Tropen*) is necessary, as the case study area is located within this eco-zone. The differentiation of the humid tropics with summer rains to neighbouring eco-zones is based on hygric and thermic criteria (see Schultz 2008:291ff.).

Figure 12 gives an overview of selected components and their characteristics for the eco-zone of the humid tropics with summer rains as well as basic information on land-use. With regard to the analysis of vulnerability and sustainability of farming systems in Makrugbeh, it is necessary to have a closer look at the conditions of arable land-use in that eco-zone.

Component	Characteristics
Climate	- consistent temperature gradient throughout the year - mean monthly temperature constantly above 18 °C - dry season (in winter) lasts from 2,5 to 7,5 months
Soils	- deep pedogenesis through intensive and long-term weathering - increased development of Fe- and Al-oxides - low content of silicates - intensive bioturbation - zonal soils: Lixisols, Nitisols, Vertisols
Vegetation	- closed vegetation cover - arid eutrophic savannah - moist dystrophic savannah *(specific vegetation cover depends on regional hygric and thermic factors and soil characteristics)*
Land-use	- dense agrarian land-use - rain-fed agriculture - shifting cultivations - partly large-scale farming of cash crops on plantations

Figure 12: Selected eco-zonal characteristics of the humid tropics with summer rains (Source: Schultz 2008).

Weischet (1980) draws a rather negative picture of tropical rural livelihoods in his work *"Die ökologische Benachteiligung der Tropen"* ("The ecological disadvantage of the tropics", translation by the writer). Based on the description and analysis of physical and ecological factors, he evaluates the challenges and potentials for land-use in this eco-zone. His final conclusion that the ecological difficulties for land-use in the tropics explain the low level of human development in the respective region is criticised repeatedly. Nevertheless, he gives insight in the problematic relations of climate, soil processes and food production potentials. Due to specific hygric and thermic characteristics, the soils of the tropics have following limiting factors for arable land-use: Relatively low content of minerals[26] due to intensive weathering processes and leaching; Low content of organic material in the upper soil horizon; And consequently low cationic-exchange-capacity (CEC)[27]. Specifically in coastal West Africa, "*[s]oils are often acidic and tend to fix high amounts of P. The probability of crop failure under low-input agriculture is high due to low inherent soil fertility* (Grenz/Sauerborn 2007:53)". These limitations can be adjusted up to some extent through specific agronomic practice. Like every other eco-zone, the (humid) tropics have specific limiting factors as well as others, more advantageous characteristics (e.g. high water,

[26] Among them are essential plant nutrients such as K^+, Ca^{2+}, Mg^{2+} or P^{3+}.
[27] The cationic-exchange-capacity (CEC) describes the capacity of the soil to bind cations temporarily to soil components and to make them available for plants if required. Next to humus matter, certain groups of tone minerals have a rather high CEC. However, these tone minerals do not occur augmented in tropical soils due to intensive desilification processes (see Weischet 1980:20f.).

light and heat supply) that are balancing each other. Consequently, the farmers need to adapt their agricultural activities to local conditions.

Dominant traditional farming system in the humid tropics is shifting cultivation (see Bremer 1999:257ff. and Weischet 1980:14ff.), that is adapted to the described challenging ecological situation in the eco-zone. This land-use system is characterized by the change of the actual farming site every year: The whole farm land is subdivided into different sections. Every year, respectively every new planting season, the farmer brushes and cleans one section by cutting and burning the vegetation cover; Usable trees remain standing. He can then work the land and grow his crops what is often done in mixed cropping systems. After harvesting, different crop(s) with preferably different nutrient requirements and physical characteristics (for example root depths) are planted. Perennial crops remain for some years. After several planting seasons it is necessary to leave the respective piece of land fallow, for it to recover and regain an adequate nutrient status (e.g. through weathering processes or external input).

With regard to the definition of sustainable farming in chapter 2.4, it is too simplistic, to call this farming system sustainable on the single cause that it does not include application of synthetic fertilizer or other inputs. "*Crop production need not be modern, highly mechanised and dependent on agrochemicals to be ecologically unsustainable (…). Although traditional farming foregoes synthetic input, it must not be considered organic, since it [often,* added by the writer*] neglects soil quality, whereas enhancing soil quality lies at the heart of organic agriculture* (Grenz/Sauerborn 2007:56)."

Shifting cultivations is on the other hand not per se a non-sustainable farming system – as often assumed (Bremer 1999:260). It can sustain the food demand of the local population and the soil can indeed gain back sufficient nutrients for repeated use after a certain period of time. It becomes problematic, as soon as the available arable land per capita is decreasing, e.g. through population growth, land degradation or demand of land from other economic sectors (Grenz/Sauerborn 2007:51f.). If the yield per area is not increased proportionally through changes in agronomic practice, it is inevitable to shorten the fallow period, hence the time for soil regeneration. With time, the soil fertility of the land will decrease and consequently the yield will decline (Schultz 2008:314). This can have severe impact on food security and the socio-economic situation of the affected population, depending on the respective livelihood context.

5.1.2 Brief introduction to post-war Sierra Leone

Sierra Leone gained special medial attention in the 1990ies, when one of the cruellest civil wars of that time overrun the country. The destructive power of the war is still visible nowadays with many people suffering from physical or psychological traumata and from loss of their homes and other livelihood assets. The country's infrastructure shows signs of destruction as well as lack of maintenance, e.g. the road transport system, electricity and drinking water supply and the education and health care system.

These conditions explain the ranking of Sierra Leone at the bottom of the Human Development Index (HDI) since several years. In the Human Development Report (HDR) of 2010 it ranges on rank 180 out of 187 countries (UNDP 2010). Although the index as well as its underlying criteria[28] improved slightly for Sierra Leone over the past years, the health and education situations are still very poor, even for the Sub-Saharan context[29]. The general HDI of Sierra Leone is 0.336 in 2011, with a present life expectancy at birth of 47.8 years (UNDP 2011:137). Central indicators of the general livelihood status and the socio-economic and political situation will be described in more detail.

Sierra Leone is subdivided into different administrative parts: Three Regions and the Western Area, ten Districts, including several Chiefdoms, which are divided into Sections. Makrugbeh village is the Headquarter of Makrugbeh Section, located in Tane Chiefdom, Tonkolili District in the Northern Region of Sierra Leone (see the location of Tonkolili District in figure 14). With a corruption perceptions index of 2.4 in the most recent report of Transparency International (2010), Sierra Leone ranges in the section of highly corrupt nations[30]. The high corruption rate influences general development processes and can hinder positive incentives. According to UNDP (2011:150), 13.1 percent of the population in Sierra Leone are vulnerable to poverty, whereas 53.2 percent are already living in extreme poverty, meaning they are living under the poverty line of 1.25 USD per day.

The general health situation and the status of food security are rather critical for Sierra Leone. The maternal mortally is one of the highest worldwide with 970 cases of death per 100.000 births (2011:149). This number is extremely alarming, even compared to

[28] The calculation of the Human Development Index is mainly based on the following three indicators: Life expectancy at birth, years of schooling, and GNI per capita.

[29] The region of Sub-Saharan Africa ranks 0.463, with a worldwide average HDI of 0.682. The highest rank is 0.93 (Norway) and the lowest 0.286 (Democratic Republic of the Congo).

[30] Sierra Leone ranks 134 out of 178 nations. The countries' indices range from 9.3 (Denmark, New Zealand and Singapore as least perceived corrupt countries) to 1.1 (Somalia), whereas 41.5 % of investigated countries have an index lower than 3.0 (see Transparency International 2010).

the region of SSA as a whole, where 619 mothers die per 100.000 births. Worldwide the relation is 176 to 100.000. Welthungerhilfe/IFPRI (2006:39ff.) analyze the post-war situation in Sierra Leone with regard to food security. They indicate the strong devastating moment of the civil war with its impacts still affecting people's livelihoods and food security. Stunting prevalence of children below five years of age ranges between 40 to 50 percent, indicating the occurrence of malnutrition and food insecurity (CCAFS/CGIAR 2011:23). The Global Hunger Index[31] (GHI) of Sierra Leone experienced a decrease from the category of *extremely alarming* to *alarming* within the last years. Nevertheless, it is inadequately high with presently 25.2 points, what makes rank 71 out of 81 countries (Welthungerhilfe et. al. 2011).

Sierra Leone is a country in the humid tropics, experiencing one rainy season from May to November (summer rains) and a dry season from November to April (see figure 13).

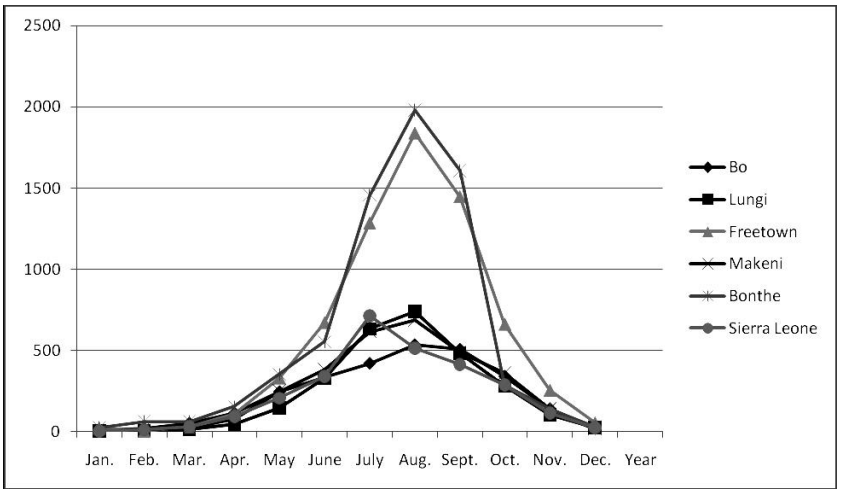

Figure 13: Average monthly rainfall (in mm) of Sierra Leone at selected stations for the period 1961-2010 (Source: Lansana/Bockarie 2011:6).

Depending on regional characteristics of vegetation cover, agricultural activities and local climatic conditions, different agro-eco-zones can be identified in the country. Roughly 40 percent of Sierra Leone's land area is covered with forest. However, the areas of primary forest are reducing drastically (UNDP 2011:156). Increasing deforestation and degradation of forests and land lead to the destruction of primary vegetation and increases savannization processes. The reasons for increasing degradation are manifold, including timber production and the practice of shifting cultivations. The case study village Makrugbeh is located in the eco-zone of transitional

[31] The GHI is calculated annually by IFPRI on basis of the following three indicators: Undernourishment, child underweight and child mortality in even weighting.

rain forest and savanna woodland, few kilometres south of the District Headquarter Magburaka (see figure 14).

Figure 14: Map of agro-climatic zones in Sierra Leone (Source: SLARI 2011).

The Sierra Leonean population relies widely on agriculture. The rural sector is of central importance for the country's economy. Roughly two thirds of the population depend on agriculture for sustaining their livelihood and almost half of the GDP (45.25 percent in 2008, with 30 percent coming from crop production) is gained from agricultural production, processing and trade (Statistics Sierra Leone 2008).

Most important staple food is rice, produced either as wet-rice in swamps and on bolilands (periodically irrigated areas) or rain-fed on the uplands during the months of the rainy season. Before the civil war, Sierra Leone was autarkic in its rice production, but the impact of the war as well as rising population made it necessary to import more and more of the cereal, mostly from Asia (MAFFS 2011. The autarky of rice production is increasing during the years since the end of the civil war in 2001. For 2009, Sierra Leone was self-sufficient in its rice production by over 90 percent (MAFFS 2008).

However, recent developments in the national agriculture and in the rice prices may increase the dependence on rice imports in the future.

Next to rice, other main crops produced in the country are (see MAFFS 2008): Cassava, sweet potato, groundnuts, maize, other legumes (cow pea, black eyed beans etc.), and vegetables (cucumber, hot pepper, garden eggs etc.). Major cash crops that are exported are coffee and cocoa. These are mainly produced in the Southern and Eastern District, not in the Northern area where the case study village is located. The production rates of selected field crops for the year of 2009 are presented in figure 15.

The agronomic production and variety of products differ according to the agro-eco-zones within Sierra Leone. In general, most farmers are practicing subsistence farming on small scale farms.

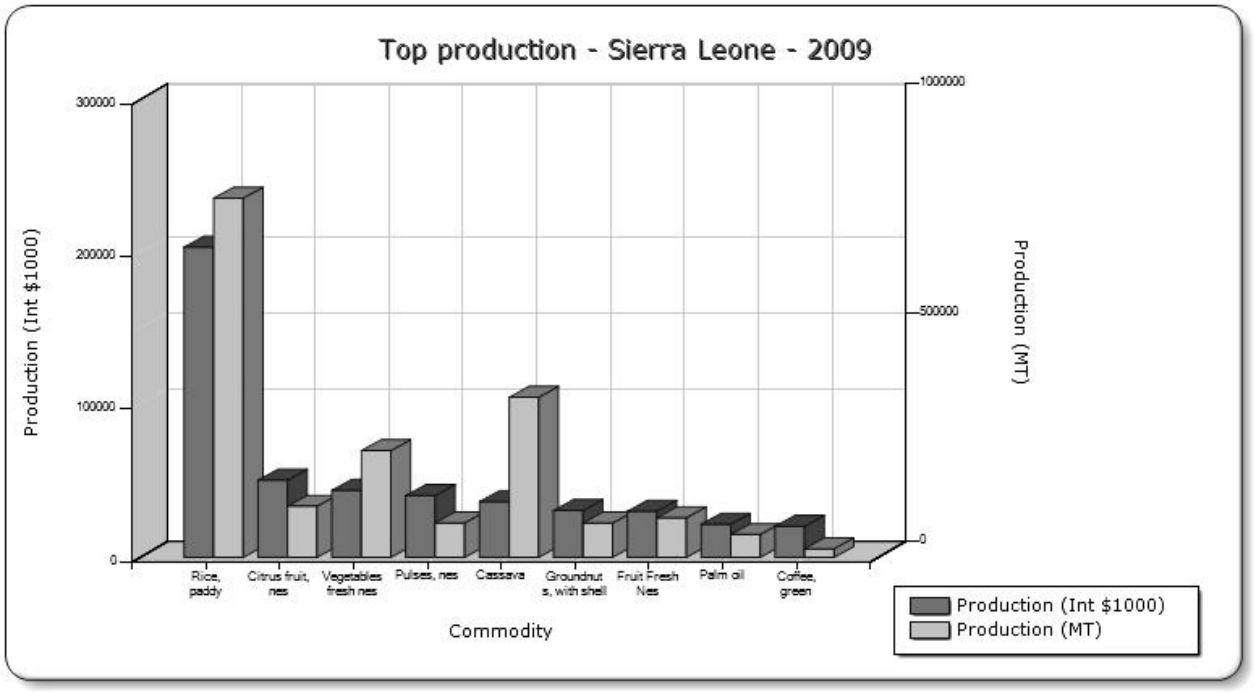

Figure 15: Crop production in Sierra Leone for 2009 (Source: FAOSTAT 2011).

Summing up, Sierra Leone is facing several economic, ecological and social challenges, partly related to the devastating moment of the civil war that overrun the country in the 1990ies. The rural sector plays an important role for the country: Major parts of the population are living in rural areas and sustain their livelihoods through farming activities. Agricultural production is of major importance for the country's economy.

5.2 Empirical results and findings of the VASA

According to the framework of analysis, the empirical findings from the case study assessment are presented in the three components of vulnerability on farm-level: (1) Baseline vulnerability and food insecurity, (2) risk exposure to climate change and (3) coping and adaptation capacity. It is assumed that the sustainability of a farming system correlates with its vulnerability. As the findings from the sustainability analysis are of basic importance for the discussion of the status of vulnerability, the results from the RISE questionnaires are presented first. The findings are then integrated in the discussions of the vulnerability assessment.

In general, the analysis is based on the primary data from the field research. However, in every chapter these data are being cross-checked with secondary data from reports of governmental bodies and international organizations (data triangulation).

5.2.1 Results from the sustainability analysis with RISE

It is assumed that the status of sustainability of a farming system correlates with its baseline vulnerability and the coping and adaptation capacity. The grade of sustainability of farming households in Makrugbeh was analysed with the tool RISE and gives insight in the economic, social and environmental sustainability on farm-level. The method RISE was conducted for three farming households. This small number of cases is balanced partly by the high degree of homogeneity[32] among the rural poor households in Makrugbeh. Therefore, the results and findings allow a certain generalization for the village as a whole.

Before presenting the findings from the RISE analysis, the applicability of this method in the context of the case study area is evaluated. The overall application of RISE 2.0 in Makrugbeh can be described as partly successful. In general, the participating farmers showed interest in RISE and were very open to the questionnaire and the discussions. However, the writer faced several obstacles during the field visits: First, the version of RISE 2.0 is only available in an online version so far. As there is neither electricity nor internet access in Makrugbeh, the questionnaire had to be printed out, filled out

[32] The writer bases the assumption of high degree of homogeneity among the farming households in Makrugbeh on the following information: The focus group discussion and the results of the standardized questionnaire show that all households in Makrugbeh are engaged in farming activities; Agricultural production and trade is the single source of income and basic commodities (with very few exceptions such as the blacksmith and teachers, that have secondary, non farm-related income); The farm size, components, crops and agronomic practices hardly differ among the households; The households are located in the same ecological, socio-economic and political framework and are confronted with similar challenges and threats.

manually and later input in the online form, what made the whole process very time-consuming. The high degree of detailed information required and the overall length of the questionnaire, containing more than 50 pages, was tiring for the farmers. Furthermore, the farmers had difficulties with some of the expressions used in the questionnaire. Additionally, many of the information and data requested could not be given by the farmer. Often, single data needed to be estimated or regional data were used, provided by the SHL. In some cases it was not possible to estimate or replace the missing data completely. Therefore, some parameters could not be calculated. This leads to a reduction of reliability of the indicator scores. For the indicator "Economic viability" none of the participating farmers could give sufficient valuable information on annual income, expenditures and other financial factors as none of them is doing regular household budgets. Eventually, the writer decided to skip this indicator for the analysis.

Another indicator that is not included in the analysis is "Animal husbandry". None of the participants is active in livestock farming and the very few sheep and goats in the village are purely held for own consumption. Thus, animal husbandry is not playing any important role for the performance of the farming activities.

The scores of the indicators for the three participating farmers in Makrugbeh are listed in figure 16. The indicators range between 0 and 100 points and the results are divided into three categories: (a) Problematic level with need for action (0 to 33 points); (b) Critical status with recommendation of further scrutiny (34 to 66 points); And (c) positive results and good performance with regard to sustainability (67 to 100 points). The results shall not be interpreted as pass or fail sustainability test but give insight in individual challenges and potentials on farm-level.

Indicators		**Farm 1**	**Farm 2**	**Farm 3**
Ecological	Soil use	35	55	51
	Animal husbandry	-	-	-
	Nutrient flows	55	53	53
	Water use	58	58	62
	Energy & Climate	40	67	40
	Biodiversity & Plant protection	70	69	72
Social	Working conditions	33	43	34
	Quality of life	52	-	59
Economic	Economic viability	-	-	-
	Farm management	29	29	26

Figure 16: Summary of the RISE-indicators and their scores for farm 1, 2 and 3 in Makrugbeh.

For all three farms in Makrugbeh, the economic indicator “Farm management” shows the lowest scores and is located in the area of a problematic status of sustainability with need for action. The ecological indicator “Biodiversity & Plant protection” has the best results and is located in the area of good performance with regard to sustainability for all three farms. All others range in the critical category with single cases that show lower or higher numbers.

The average performance of the sustainability indicators in Makrugbeh are presented in the sustainability polygon in figure 17. The figure is excluding the two indicators without valid database: “Animal husbandry” and “Economic viability”. It makes the above findings visible, with most indicators ranging in the critical category.

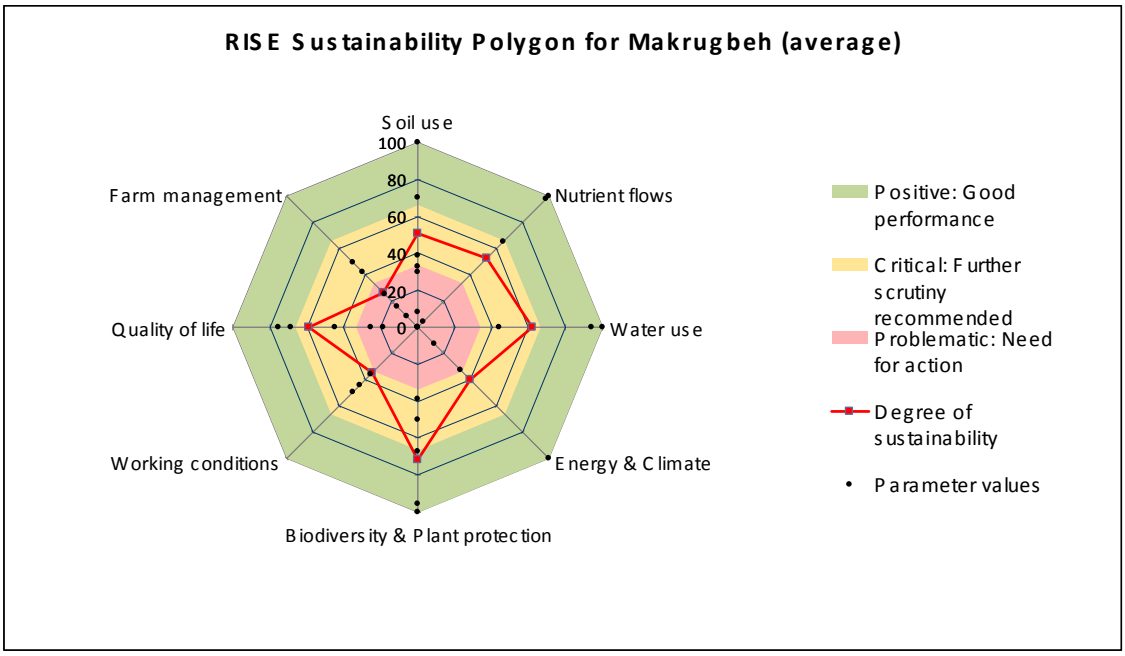

Figure 17: RISE sustainability polygon for Makrugbeh, based on the average scores of farm 1-3, excluding the two indicators without valid database.

The indicator “Soil use” includes parameters, such as general soil management, soil pollution and compaction. The lack of external inputs and heavy machinery is evaluated positively for the farming systems. However, the overall crop productivity is very low and the effects of erosion minimize the sustainability on farm-level. With regard to the indicator “Nutrient flows”, low nitrogen- and phosphorus balances have negative effect on the agricultural performance. Although the parameters for water supply and water use intensity are positive, the absence of water management and some risks for water quality reduce the indicator “Water use” to a critical level. In the category of “Energy &

Climate", the positively low energy consumption and the GHG balance is balanced by lack of proper management. The indicator with highest scores, "Biodiversity & Plant protection" is based on high diversity and protection of ecological priority areas. Lower scores can be found for the parameters landscape quality and crop protection.

For the economic indicators, the lack of proper farm management in combination with insecure and often unknown financial situation makes the households vulnerable for financial threats for example through yield loss and hence increasing insecurity in income and food supply. The indicator "Farm management" is based on the following parameters with rising scores: Planning instruments and documentation, farm strategy and planning, quality management, farm cooperation, and supply and yield security.

The performance of the social indicators is throughout critical. The "Working conditions" are evaluated negatively especially with regard to low income level, problematic working times and critical work safety. The indicator "Quality of life" is based on high scores for parameters such as social life and personal freedom and values and low scores for education and financial situation.

A deeper look into the degree of sustainability on farm-level is possible by analysing the single parameters that build the different indicators in more depth. However, the objective of this case study assessment is not a detailed sustainability analysis. The use of RISE in this context shall provide an overview of the status of sustainability on farm-level in order to complement the vulnerability analysis.

Summing up, the status of sustainability on farm-level in Makrugbeh is challenging. The farming households are affected by a problematic economic situation, a critical social and a critical to positive ecological level of sustainability.

5.2.2 Baseline vulnerability and food insecurity

As described in chapter 3.4, the baseline vulnerability of a farming household is linked to its general standard of living and status of development. The more severe the occurrence of poverty and the lack of (access to) central livelihood assets, the higher is the baseline vulnerability. In context of this case study, central ecological, political and socio-economic factors are analysed for the situation of Makrugbeh. This chapter is thus providing insight in the livelihood of the farming households.

The primary data from the VASA implementation in the village give an overview of the baseline vulnerability and the status of food security for Makrugbeh. During the focus group discussion, the general livelihood situation of the village was discussed as well as specific constraints the farmers face in their activities:

Presently, the village consists of 72 households with a total population of 865 inhabitants. The average household size of the participating farmers consists of eleven inhabitants, with an average number of five children (below 18 years of age).

The health and educational service in Makrugbeh is not sufficient. There is one community health post in the village with a staff of two nurses, provided by the government. However, the provision of medical equipment and drugs is insufficient. In Makrugbeh, there is one primary school. For further education, the children have to travel by foot to the chiefdom headquarter Matotoka that is located roughly four kilometres away. In the ongoing of the focus group discussion, the focus was drawn to the farming activities and specific challenges of the farmers.

All households are engaged in farming activities, with just few having a second source of income, such as the blacksmith and the teachers. Hence, agriculture is sustaining the livelihood of the villagers: It provides food, fuel in form of firewood, fibre for construction and fodder for livestock. Additionally, parts of these products are being sold on markets for income generation. As the households are highly dependent on farming, any influence on that sector has direct impact on the general livelihood of the village. The results from the questionnaire confirm this, as none of the participants is stating a secondary, non farm-related income source. Thus, the financial assets of the households depend on their farming activities and on the agricultural performance. This induces high baseline vulnerability, because there is lack of alternative income sources or safety nets.

The analysis of the standardized questionnaire provides following information: The average farm size is seven acres. Two participants farm an exceptionally large area of 15 acres, of which major parts are in use as palmtree forests for palmoil production. The farms are composed of uplands (bush land and savannas) and swamps. The swamps are used exclusively for wet-rice production. On the uplands, the farmers plant different crops in mixed cropping systems under application of shifting cultivation. The average length for the fallow period is 7.8 years. The majority of the farmers perceive this time as not sufficient for the rehabilitation of the soil nutrient status.

All farmers are active in crop farming and only few possess livestock (sheep and goats) for their own consumption. The major field crops planted in Makrugbeh are listed in figure 18 according to the percentage of farmers plantings them. All farming households plant rice, the main staple food. Other important crops are different types of vegetables (e.g. cucumber, pumpkin, garden egg), groundnuts and cassava.

Name of crop	Rice	Vege-tables	Ground-nut	Others (millet, sweet potato)	Cassava	Corn	Hot Pepper	Palmtree (for palmoil)
Fraction of farmers planting it (in %)	100	100	93.3	80	73.3	66.7	53.3	26.7

Figure 18: Major field crops according to the percentage of farmers planting them in Makrugbeh.

The rice is either planted as sole crop in the swamps or in the uplands in mixed cropping systems. In the latter, it is combined with vegetables, cassava, corn, hot pepper and other crops on one field. Groundnuts are often planted as sole crops in the uplands.
The annual work distribution for farming households in Makrugbeh is linked to climatic conditions and seasonality. The conduction of a seasonal calendar provides basic information on agronomic activities and periodical challenges throughout the year (figure 19).

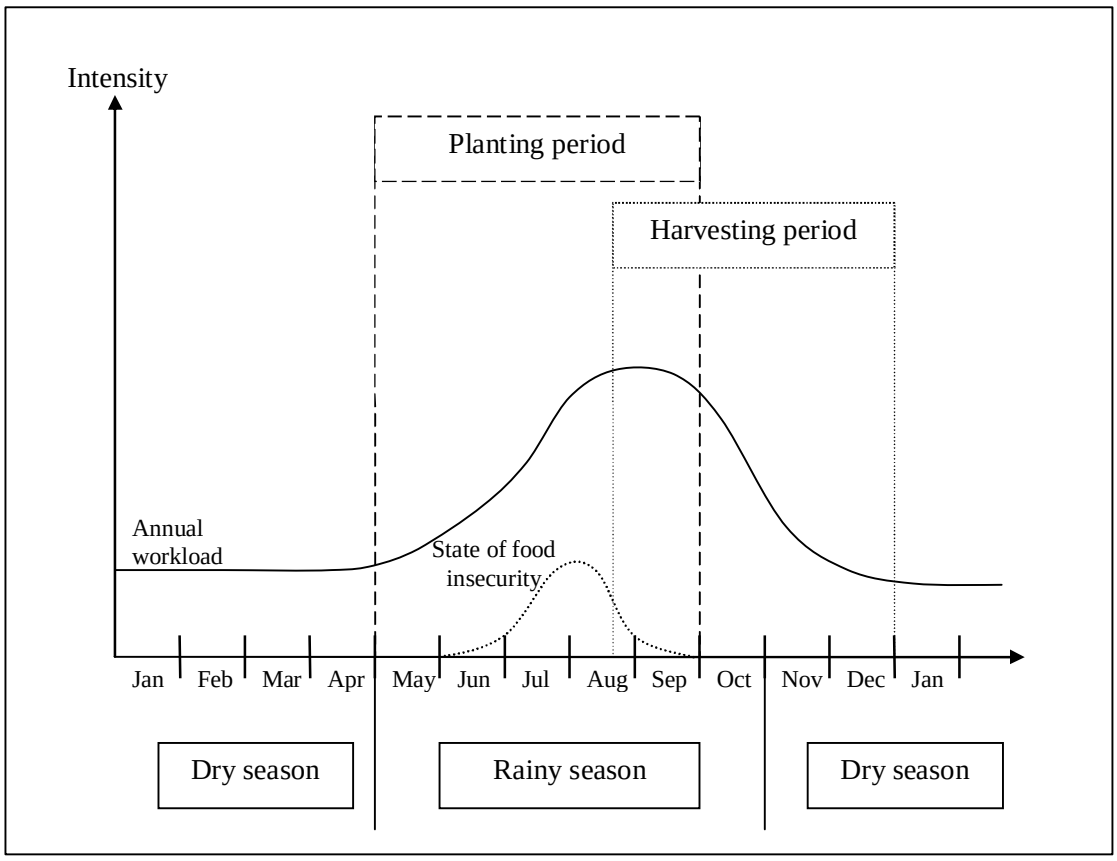

Figure 19: Timeline graph according to the seasonal calendar of Makrugbeh.

With the beginning of the rainy season in May, the planting period starts. The workload increases with continuing planting activities, as the planting sites needs to be maintained and protected (from weeds, pests and diseases) throughout. The workload reaches its maximum intensity by the last third of the rainy season. First crops are ready for harvesting. With the beginning of the dry season, the planting activities come to an end and the workload is reducing gradually to its previous intensity. The farmers indicate an annual period of increasing food insecurity during the rainy season. Before the new crops are being harvested, the food stored from last year is becoming scarce and eventually, the food is used up before the new harvest starts. This is often the case for the main staple food rice that then has to be purchased on the market. As this periodical shortening of rice is occurring all over the region, the demand and consequently the rice price increases. Eventually, some households are not able to purchase enough rice to balance the loss and suffer from food shortage and hunger.

With regard to food security, another aspect, drawn from the standardized questionnaire is of importance: Except of one respondent, all farmers experienced significant yield loss during the past years. Out of these, 80 percent state that they assume changing climatic conditions as reason for the loss. The others mention soil amendments and fertility as not suitable, what can to some extent be related to changes in climatic conditions. The fact that almost all farmers experience significant yield loss in the past three years indicates that the issue of food insecurity is of major concern in Makrugbeh. The crop yield is basic source of food and basically only source of income for major parts of the population and decreases can have severe impact on the general livelihood situation of the community.

The pair wise ranking conducted in Makrugbeh was based on the question what the farmers perceive as most challenging in their farming activities (see Appendix II). The options mentioned by the participants are: Climate change, lack of seeds, lack of fertilizer, lack of tools, and occurrence of pests. After discussing and comparing the different factors with each other, following rank list was agreed on: Most challenging is perceived to be the lack of access to sufficient seeds, followed by lack of fertilizer, climate change, lack of tools and finally the occurrence of pests. The fact that climate change was mentioned as one challenge of agriculture shows that the farmers in Makrugbeh are aware of global warming and even feel their own vulnerability to it. However, it ranks on third position out of five, thus is not perceived as the most threatening factor for their agricultural activities.

The results from the RISE analysis complement these findings: The critical status of almost all sustainability indicators shows the need for improvement on different levels. Especially the absence of regular household budgets and farm management planning increases the baseline vulnerability of the farming households, as income and expenditures are not registered and analysed. The lack of non farm-related income sources puts the livelihoods in Makrugbeh on an insecure basis with high dependency on agricultural performance. Also ecological factors, partly related to the practice of shifting cultivation with its constraints for soil fertility, lead to challenges for the sustainability on farm-level. The critical degree of the indicator "working conditions" is partly linked to high insecurity on the work place. Due to lack of proper attire and quality tools, the family members working on the farm are exposed to health risks.

Summing up the results from the field research, the farming households in Makrugbeh experience rather high baseline vulnerability: The general livelihood situation is challenging and basic needs are not sufficiently satisfied. As all households practice crop farming, agricultural challenges affect the whole village. Next to lack of financial assets for investment in tools, seeds and further inputs, the farmers experience the changing climate and its negative impact on their activities. The state of food security in Makrugbeh is generally low, with an annual peak of scarcity before the harvesting period starts.

These empirical findings are correlating with reports on and descriptions of the region and Makrugbeh from other, secondary sources: Tonkolili is one of the Districts experiencing the highest rates of poverty within Sierra Leone (see Winnebah et. al. 2006). In the latest analytical report on the issue of poverty from the Population and Housing Census, the authors describe that 71 percent of Sierra Leoneans are poor[33] compared to 29 percent non poor. The Northern Region is indicated as having the highest value of housing poverty. Main source of income in this area is the agricultural sector, especially crop farming.

By analyzing the status of food insecurity, CCAFS/CGIAR (2011:19ff.) indicate that Sierra Leone as a whole is experiencing lower average yield in main field crops, such as

[33] The dependent variable *poverty* in the report is related to the following indicators (Winnebah et. al. 2006:6): "*current repair needs of dwelling units; major roofing materials of dwelling unit; major wall material of dwelling unit; major floor material; disposal of rubbish; principal source of fuel supply for cooking; principal source of lighting; principal source of water for drinking; kind of toilet facility used; main source of information used by household; crops grown by household; ownership of livestock; access to agricultural facilities and ownership (availability) of working consumable durables.*"

rice, maize, sorghum, millet, beans, wheat and cassava, compared to other regions in the global tropics.

In the National Adaptation Plan for Action (NAPA) for Sierra Leone, GoSL/UNDP (2007:10) indicate special challenges for the country's agricultural sector with regard to climate change impacts and food insecurity. The authors conclude that farming households are especially vulnerable due to the following reasons:

- Almost completely dependency of agriculture on rain-fed conditions
- Expected increasing environmental constraints:
    - Bush fallow system with shortened fallow period of five to seven years
    - Increasing demand for forest and agricultural products and resources (minerals, fuelwood etc.)
    - Bush fires increase (savannization process)
- Poor support mechanisms (infrastructure, seeds, resources, knowledge)
- Socio-economic constraints within the sector
- Policy and legislation constraints (e.g. with regard to land tenure)

The empirical findings from the field research in combination with information from secondary sources show a rather critical picture of Makrugbeh with regard to its baseline vulnerability and the status of food security. In combination with a high risk exposure to climate change, farming systems with high baseline vulnerability are endangered. The degree of risk exposure to climate change for rural poor households in Makugbeh is discussed in the following section.

5.2.3 Risk exposure to climate change

Every region on earth is to some extent influenced by climate change and every human livelihood faces present or future impacts on its assets and strategies by changes in the atmosphere. In many areas, farming households are especially sensitive to climate change, as their activities highly depend on climatic conditions.

In Makrugbeh, the farmers are aware of global climate change and they are already experiencing its local impact on their farming activities. The issue was discussed intensively during the focus group discussion: According to the participants of the discussions, the beginning of the rainy season with the first heavy rains in May was for many years very predictable. The farmers had adapted their annual activities to the regular occurrence of rainy and dry seasons. However, in the past years, the rainfall pattern changed significantly: The first rains occur later than expected and the total

quantity of rains is perceived smaller nowadays than in the past. Furthermore, throughout the rainy season, the traditional sequence in rainfall intensity (beginning with heavy rains and thunderstorms, continuing with lighter but more frequent rains, and finally ending again with heavy storms) is no longer reckonable. These climatic changes were also reflected when discussing and filling in the seasonal calendar: The farmers could not define precisely the end of the dry season and the beginning of the rainy season. Perceptions and experiences of annual derivations in rainfall patterns do not necessarily indicate long-term climatic changes. However, in the case of Makrugbeh, the farmers describe not just single events but general changes that are visible since several years.

These changes have a negative impact on the activities of the farmers in Makrugbeh. In the focus group discussion, several participants mentioned, they experienced crop failure due to the absence of expected rainfall. These experiences are also visible in the analysis of the standardized questionnaire as discussed in the previous chapter. In general, there is confusion about when to start with the planting of different crops, as the beginning of the rainy season is no longer predictable. During the preparation of the pair-wise ranking matrix of agricultural challenges, climate change was mentioned as one central option. Although it was not rated highest, this indicates that the farmers are aware of the challenges they have to face with regard to climate change. The risk exposure of rural poor households in Makrugbeh to climate change is evident for its inhabitants.

The climatic changes and its impacts that are described by the farmers of Makrubgeh, correlate with the predictions from climate scenarios and assessment reports from secondary sources. According to UNDP (2010:164), 52.1 percent of Sierra-Leoneans believe that humans cause global warming and 74 percent perceive global warming as serious threat[34]. An analysis report from the Climate Change Project of the UNDP and IFPRI in Freetown offer insight in specific scenarios for Sierra Leone with regard to climate change, as well as special vulnerability analysis of the agricultural sector. Their predictions and recommendations are based on a set of four different climate models[35] using different calculations of future CO_2 concentration in the atmosphere. These data build the basis for climate scenarios, analyzing expected changes in temperature,

[34] In the region of Sub-Sahara Africa, 49.5 percent believe that humans cause global warming. Worldwide, 53.5 percent agree on that and 67.9 percent perceive global warming as a serious threat (UNDP 2011:164).

[35] The models used in that study for climate scenario development are: UKTR, HDCM2, ECHAM4 and CSIRO-TR.

precipitation, evaporation and sea level up to the year 2125 (Bockarie/Lansana 2011): For the mean monthly temperature, all scenarios predict an increase throughout the year for the coming decades. The analysis of precipitation patterns show either similar values than presently or reductions of overall rainfall up to nine percent. In case of evaporation values, most scenarios predict a decrease in the future. The sea level is supposed to rise between 0.5 and 3.5 metres. The agricultural sector is predicted to be highly vulnerable to these climatic changes and further, secondary impacts (Thomas et. al. 2010): Most field crops will decrease in their yield, among them the main staple food rice.

GoSL/UNDP (2007:19) describe present and future threats of climate change to Sierra Leone in the NAPA. The authors discuss the potential hazards according to their occurrence, their impacts, most vulnerable areas to this threat and most vulnerable sectors. The different hazards and their characteristics are presented in figure 20.

Hazards	Occurrence	Impacts	Vulnerable areas	Vulnerable sector
Change in rainfall	Current	Loss of crops and livestock	Northern and Eastern regions	Agriculture, livestock, water resources and health
Flooding	Future	Loss of life, crops, livestock; damage to infrastructure and settlement areas; disease outbreak	Western area, Eastern, Southern and Northern regions	Agriculture, livestock, water resources and health
Dry spells	Current	Crop failure; fresh water shortage; disease outbreak; increase in bush fire; hydro power decline	Northern, Eastern, Southern regions and Western area	Agriculture, water resources, fisheries, forestry, health, energy
Sharp temperature increase	Future	Heat waves; drought; frequent storms; crop failures; sea level rise; biodiversity threat	Whole country	All sectors
Sea level rise, coastal flooding and coastal erosion	Current	Loss of property, beaches; population displacements; coastal flooding	Northern, Southern, Eastern regions and the Western area	Tourism, fisheries, agriculture
Sea level rise and salt intrusion	Current	Reduction in fresh water quality; fish migration; coastal area degradation	Northern and Eastern Regions, Western area	Tourism, agriculture, fisheries, water resources
Increase in storm wind activity	Current	Loss of life, property; air pollution and agricultural losses	Whole country	All sectors

Figure 20: Current and future climate change impacts in Sierra Leone (Source: GoSL/UNDP 2007:24).

All in the NAPA described climatic threats are influencing the agricultural sector and all are predicted to occur in the Northern Region, where the case study community is

located. The hazard “change in rainfall” in combination with “dry spell” is correlating with the descriptions of the farmers during the focus group discussion of already occurring impacts.

The risk of sea level rise, salt intrusion and coastal storms and flooding is listed to have impact on the agricultural sector in the Northern Region, too. As five to ten percent of the Sierra-Leonean population is living in coastal areas (defined here as max. ten metres above sea level), these risks due to sea level rise can have major negative impacts (The World Bank 2010:103). However, Makrugbeh is not affected directly by coastal and sea-level alterations, as it is located far off the coast line. But, as nationwide occurring socio-economic threats influence general livelihood assets, the consequences of climate change impact on other sectors and regions in Sierra Leone might be linked to the farmers of Makrugbeh eventually.

Summing up, rural (poor) households in Makrugbeh are exposed to a certain risk of climate change. Some of the hazards are already occurring and influencing the agricultural sector among others. Other threats are predicted to occur in the future. In order to balance the negative effects, the farming households need a certain degree of coping capacity for climatic threats and adaptation capacity for ongoing and future alterations.

5.2.4 Coping and adaptation capacity

In this chapter, the capacity of the farmers in Makrugbeh to cope with already occurring and future climate change impacts is discussed as well as the ability to adapt to long-term alterations. The coping and adaptation capacities of rural farming systems are strongly related to the resilience of the agro-eco-system and hence to its underlying sustainability. Therefore, the findings of the sustainability analysis with RISE are included to give an overview of the status of ecological, economic and social sustainability in the village. As presented above, the findings of RISE draw a rather critical picture of the status of sustainability on farm-level in Makrugbeh. These conditions lead to a low coping and adaptation capacity of the households.

Coping capacity describes the ability of the farming systems, to balance occurring stress and hazards. In Makrugbeh, climate change is already influencing the farming activities, especially through the alterations in precipitation patterns. As indicated above, the farmers face problems with the increasing unpredictability of the rains. Futhermore, most households experience yield loss due to different reasons and they suffer from periodical increase of food scarcity. During the focus group discussion, the farmers

indicated the difficulties they have in coping with these challenges. The lack of regular household budget plans and adapted farm management is contributing to these constraints: The households are not aware of their annual or seasonal expenditures and income. There is no financial safety net e.g. through savings. In case of emergencies, such as immediate unexpected crop failure, the farmers are unable to balance the pressure. Another factor contributing to these insecurities is the lack of secondary income sources. The high dependence on agricultural performance to sustain the rural livelihoods inherits further dangers: Ecological factors have direct impact on the financial situation of the households as well. Although the ecological indicators show the highest scores in the RISE analysis, most of them range in the critical category. Many factors in the farming activities need to be reconsidered and eventually altered to a more sustainable manner in the long run, e.g. the present practice of shifting cultivations or the cropping systems.

Alterations in agronomic practices are often suitable adaptation measures. The capacity of farming systems, to adapt to ongoing and future long-term changes is inevitable for a sustainable livelihood. This is especially important in cases such as Makrugbeh, for which climate scenarios predict several impacts on the agricultural sector. The pressure on arable land and hence on soil fertility needs to be balanced through locally adapted measures. However, the critical economic situation and the financial limitations limit the ability to adopt certain practices for the households, as some of the possible adaptation measures require – at least initial – (financial) input. In general, the indicators of a sustainable farming system are on a critical level in Makrugbeh, limiting the capacity of the households to cope with and adapt to climatic and other changes.

The results from the field data are similar to findings from secondary sources, stating that rural poor households in Makrugbeh, respectively in Sierra Leone as a whole, have rather low coping and adaptation capacity to climate change and its impacts. In the case of the rural sector, the vulnerability analysis of the Climate Change Project gives further insight. They assess the adaptive capacity of main field crops towards predicted climate changes in Sierra Leone. The country's main staple food rice is rather adaptive to changes in soil conditions. However, due to the expected reduction of overall water availability, rice production can be affected, as it is mainly grown as wet-rice in swamps and riverbanks. Cassava is highly adaptive to drought and is not dependent on specific soil amendments. For most other crops, the respective impact of climate change depends on specific local conditions. In general, yearly fluctuations in yield can already

be related to changing climatic conditions, as Sierra Leone is presently experiencing the impact of global climate change. The adaptation capacity of farming households depends partly on the choice of crops, the agronomic practices (e.g. additional irrigation, external nutrient input etc.) and therefore also on the general socio-economic conditions. As the farmers in Makrugbeh lack financial possibilities for diversification as well as for tools and fertilizer, the adaptation capacity is rather low.

The observed high baseline vulnerability and the prevailing occurrence of food insecurity contribute partly to the lack of adequate coping capacity to climate change. With their study on hotspots of climate change and food insecurity, CCAFS/CGIAR (2011:28) indicate that Sierra Leone is a country with low coping capacity to climate changes[36]. The authors see occurrence of malnutrition as indicator for chronic food insecurity, which is correlating with low adaptation capacity.

Concluding, the coping and adaptation capacity of farming households in Makrugbeh to climate change is low. Main challenges arise through the critical status of sustainability and general livelihood constraints such as food insecurity. The potentials for reducing vulnerability to climate change and food insecurity by increasing the sustainability of farming systems is discussed for Sierra Leone as a whole in the following chapter. Therefore, the findings from the case study analysis are summed up and later on expanded on a broader level.

5.3 Recommendations for reducing vulnerability and enhancing sustainability

The implementation of VASA and the discussion of the results offer insight in the vulnerability of poor farming households in Makrugbeh to climate change and food insecurity and the status of sustainability on farm-level: The rather high status of baseline vulnerability in the village is related to ecological constraints for farming activities as well as a challenging socio-economic situation. Climate change scenarios support the descriptions of participants in the focus group discussion that changing climatic conditions have a negative impact on the agricultural sector. Due to some constraints in the sustainability of the farming systems, the households have a rather low coping and adaptation capacity to present and future climate change impacts and food insecurity. These results lead to the conclusion that rural poor households in Makrugbeh have a high vulnerability to climate change and food insecurity.

[36] Under the consideration that chronic food insecurity (in this case deduced from occurrence of malnutrition) can serve as proxy for low coping capacity (see CCAFS/CGIAR 2011:28).

The results from this case study can to some degree be projected to similar farming systems in Sierra Leone, as poor small-scale subsistence farmers, applying the method of shifting cultivation, are facing similar limitations and challenges: The agricultural conditions of the eco-zone of the humid tropics with summer rains lead to constraints in soil fertility and unsuitable land use patterns can have severe impact in the long run. The socio-economic situation for the farmers is challenging, too. General livelihood assets are still being affected negatively due to the period of the civil war. The standard of living is low and basic needs are not being fulfilled sufficiently, partly related to high level of corruption and lack of good governance on national level.

This chapter deals with the question on how the identified challenges can be faced and balanced by increasing sustainability and reducing vulnerability of the farming systems in the case study area and in other regions under similar conditions. First, the potentials on farm-level especially with regard to agronomic practices are discussed. Later, the need for multi-level initiatives is presented.

There are different potential ways for reducing vulnerability and increasing sustainability on farm-level. Based on the findings from the case study, the writer suggests different measures for reducing vulnerability to climate change and food insecurity on farm-level in Makrugbeh (figure 21).

Recommendation	Explanation
Increase the length of the fallow period in shifting cultivation if possible.	The longer the time of the fallow period, the higher the chances that the soil nutrient status can regenerate sufficiently for the next planting period.
Increase the use of swamp areas and semi-flooded lands instead of uplands.	Climate scenarios and predictions show the threat of drought and water scarcity. By using increasingly (semi-) flooded lands, these threats can be balanced partly.
Increase the practice of intercropping and mixed cropping, also with inclusion of trees.	Mixed cropping systems often have positive effect on soil amendments and its fertility status. Leguminous crops and trees enhance the nitrogen content of the soil. Some mixed cropping systems can even lead to yield increase (compared to sole cropping).
Diversify the used crop varieties.	High crop diversity reduces the dependence on the performance of just few crops. In case of diversity in food crops, the level of nutrition security rises. The higher the diversity of an agro-eco-system, the higher is its resilience.
Establish (community) seed banks.	(Community) seed banks can provide access to seeds in times of economic constraints.
Avoid (further) deforestation and forest degradation.	The degradation of forests and lands can lead to increasing erosion and hence to the reduction of soil fertility and eventually to crop failure and yield decline.
Plant trees for balancing the micro climate and for securing water catchment areas.	Water catchment areas need to be protected in order to secure the water supply chain and to avoid increasing water scarcity.
Get regular access to information on weather forecast and climate predictions if available.	These information can help for planning of planting season, for preparing in case of droughts etc.

Get information on adaptation capacity of different crops to climatic changes if possible.	On basis of such information, the use of adaptive crop varieties can be increased and hence the adaptation capacity of the farming system is being strengthened.
Assess the potentials of livestock farming and trade.	Increasing animal husbandry can provide variety in diets and hence improve food and nutrition security, especially in times of crop failure and yield decline. The livestock trade can provide secondary farm income.
Assess and use potential secondary, non farm-related sources of income.	Other sources of income, especially non farm-related, diversify the farm household and reduce the sole dependency on agricultural performances and trade.
Develop regular household budgets and farm management strategies.	Regular annual household budgets can provide an overview of critical sectors in the farm economic performance. Adapted farm management strategies shall include present challenges (e.g. food shortages) and expected threats (e.g. climate change) for enhancing adaptation and coping capacity.

Figure 21: Recommendations for reducing vulnerability and enhancing sustainability on farm-level in Makrugbeh.

These recommendations are based on the findings from the field study and they are solely reflecting the writer's perception. They include ecological as well as economic measures ranging between climate change adaptation and improvement of farm management. In the following, recommendations from secondary sources with regard to Sierra Leone as a whole are discussed.

Several ways are imaginable for increasing the capacity of farming households to balance and cope with climatic stress. In the NAPA of Sierra Leone, several adaptation options for the agricultural sector are presented. They are listed in ranking order with regard to highest perceived impact (based on a multi criteria analysis) (GoSL/UNDP 2007:28):

1. Develop irrigation and land drainage system for agriculture
2. Develop and implement agricultural land-use and land cover management plans
3. Promote swamp land farming
4. Cultivation of drought resistant crops
5. Improve food storage facilities and establish seed banks
6. Train/educate professional and technical staff including agricultural extension workers on climate change and agriculture

The recommendations are correlating to major parts with the measures, suggested by Thomas and colleagues (2010) from the Climate Change Project. The authors mention following possible adaptation measures with synergies to climate change mitigation: Promotion of multi-cropping and crop diversification, development of seed banks, promotion of sustainable agricultural management practices, and reducing the use of

some pesticides. The most suitable measures depend on the specific local conditions and potentials.

The task of enhancing sustainable agriculture and hence of reducing vulnerability of the rural poor needs to be based on a multi-level approach. As discussed above, regional and national socio-economic and political framework is influencing the livelihood of poor farmers on local scale. Therefore, the degree of sustainability of farming systems and hence their vulnerability is not only dependent on the performance of the farming household itself. National and international political decisions are affecting the accessibility of livelihood assets and can limit possible livelihood strategies.

For example, in Sierra Leone the issue of *land grabbing* (see chapter 2.3.1) is of rising concern for several small-scale farmers throughout the country (see Baxter 2010 and Mousseau/Sosnoff 2011). International companies from Europe and Asia are leasing thousands of hectares of arable land for the production of biofuels from sugarcane or oilpalms. Other interest in land is rising with regard to Sierra Leone's richness in mineral resources, such as iron ore, gold, diamonds and rutile. Long-term land-lease agreements over large areas are agreed on between the Sierra-Leonean government and the respective mining company[37]. Consequently, the question of sustainable food production in Sierra Leone is not only a matter of ecological, social and economic sound farming methods but also on lend tenure systems and the accessibility of arable land for farmers. Therefore, farming households are increasingly dependent on national and international regulations and decisions. A multilevel approach is inevitable in order to combat increasing challenges for rural poor households in the country. Climate change has effects on local, limited scale, but the coping and adaptation capacities of rural households rely on a strong political system, not undermining their crucial resource: Arable land. In general, good governance and hence the fight against corruption is a key factor for equal rights and possibilities and for the successful implementation of suitable adaptation and mitigation measures on national and local scale.

Within the NAPA for Sierra Leone, the need for a cross-sector and multi-level approach is acknowledged. A variety of possible adaptation measures for different sectors are presented as well as project proposals for nation-wide reduction of vulnerability of the country to climate change (GoSL/UNDP 2007). The proposed projects range from

[37] The following companies are examples for having long-term agreements with the GoSL on use of large areas of land: ADDAX Bioenergy (sugarcane production), Sierra Rutile (rutile mining), London Mining and African Minerals Limited (iron ore mining).

weather forecast systems and early warning mechanisms over sensitization and capacity building programmes to renewable energy supporting systems.

The mitigation potential of Sierra Leone is not yet discussed intensively. The country is amongst the nations that contribute the least to the global anthropogenic greenhouse effect, both in total value and per capita. Sierra Leone has an annual per capita emission of carbon dioxide of 0.3 tonnes (SSA: 0.9 tonnes, worldwide: 4.4 tonnes), with negative annual growth rate (UNDP 2010:156). Looking at this and the presently occurring and predicted future threats for different regions and sectors of the country, the focus on suitable adaptation measures seems to be more important at this point of time.

In general, more frequent and reliable data on climatic processes and agricultural performance for Sierra Leone are necessary. The decade of civil war destroyed existing databases as well as educational and scientific infrastructure. This point is also stressed by Lansana/Bockarie (2011:22ff.). They suggest following steps of improvement for more valid climate databases for more reliable predictions and climate scenario development:

- Strengthening the climate data base of the Meteorological Department
- Rehabilitation and reopening of more climate data collection and monitoring stations
- Training of personnel
- Education and sensitization of the public on climate change issue
- Creation of a Nationals Climate Change Committee and Secretariat
- Undertake research

Some of these recommendations are already faced by national and international organisations: The Sierra Leonean Agricultural Research Institute (SLARI), with financial support from DFID and The World Bank is presently rebuilding facilities for agricultural research and development (IFPRI/SLARI 2010). On international academic level, more analysis of marginalized regions needs to be implemented and considered. Reliable predictions and scenarios of climate change impacts and hence developments of suitable adaptation and mitigation measures are only possible with a valid database.

The Vulnerability and Sustainability Analysis of rural poor households in the village of Makrugbeh in Sierra Leone gives insight in the status of vulnerability to climate change and food insecurity on farm level. The empirical findings indicate the crucial role of agriculture in a changing world on local scale for one of the most vulnerable regions.

The specific challenges the farming households are facing can be balanced by improving sustainability and coping and adaptation capacities on local scale as well as by nationwide action in the area of infrastructure improvement, strengthening of the rural sector, improving land rights, supporting climate change research and others. First initiatives are already ongoing. Others often lack sufficient financing, education and sensitisation or political will.

The findings lead to the conclusion, that sustainability needs to be considered and analysed on local level. However, the broader thematic and spatial dimensions need to be considered simultaneously. The last chapter gives an outlook on the issue of sustainable agriculture for the region of the humid tropics as well as on the concept of sustainable development as cross-sector and multi-level approach.

6. Outlook: Expanding the issue of sustainability on broader scale

6.1 Potentials and challenges of sustainable agriculture in the humid tropics

On global scale, pressure on arable land and agricultural production is arising from an increasing imbalance in demand and supply of natural resources and agricultural products: Global mankind change (especially population growth and changes in production and consumption patterns) leads to an increasing demand of natural resources and products from arable land-use. But, global environmental changes - partly human induced - decrease the availability of arable land and other resources in general. This global imbalance is projected into the eco-zone of the humid tropics, where additional problems arise due to zonal typical limiting factors. With regard to ecology, soil fertility is the most challenging issue, whereas socio-economic and political limiting factors depend highly on regional specific conditions. Imaginable problems arise through low poverty status, political conflicts, marginalisation of (small-scale) farmers due to problematic land tenure system etc. The described double pressure on agro-ecosystems is affecting traditional farming systems, such as shifting cultivations, and small-scale and low-input agriculture in general. In the system of shifting cultivations, the above mentioned developments lead to the shortening of the fallow period. The lack of fallow time needs to be balanced by changes in agronomic practices, such as minimizing soil erosion, increasing soil organic matter (SOM) content, creating suitable environmental conditions for soil flora and fauna and suppressing weed growths (Sauerborn 1999:76).

As indicated in the case study of Makrugbeh, rural poor households suffer from high vulnerability to climate change and food insecurity. Sustainable agriculture can contribute to the reduction of vulnerability on farm-level. Environmental, social and economic sound farming systems increase coping and adaptation capacities and lower the baseline vulnerability of rural livelihoods. In this chapter, possibilities for small-scale subsistence farmers in the humid tropics to apply sustainable farming methods with regard to climate change and food security are presented.

With regard to food security, it is important that enough valuable food is produced in a sustainable manner and that it is made accessible for the rural poor population, hence basically, that yield is rising appropriately with increasing demand[38].

[38] In general the imbalance of high demand in field crops and decreasing availability of arable land could also be equalized by altering the demand side. As enough food to feed the global population is produced on global scale, it is hence a matter of distributing the food better. With regard to rising demand in

Grenz/Sauerborn (2007) assess the potential contribution of sustainable farming practices to food security in SSA. They discuss different possibilities to improve soil fertility in an organic manner, differentiating between potentials of using system internal materials and application of matter from outside the system. They state that in order to balance nutrient loss from erosion and other processes in a sustainable manner, it is necessary to open the nutrient cycle to external inputs in general. Application of internal produced material (organic waste, manure) would not be sufficient. Though, improvement and adaptation of farming practices could tighten nutrient cycles and enhance sustainable SOM management. Yield increase in tropical agro-ecosystems is thus not always related to improvement of the soil nutrient content. Agro-ecosystems are based on complex ecological processes and linkages that offer a variety of possibilities for human influence (Zech et. al. 1999:107). With regard to the use of legumes in agro-eco-systems, Sauerborn (1999) gives insight in potentials of leguminous crops for weed control and soil fertility improvement. Legumes (such as varieties of peas, beans, groundnuts etc.) have several advantageous characteristics, most popular is the ability to fix nitrogen on their root system. They hence increase the soil fertility by providing N in the upper soil for other crops. They are often used as under-sown crops in mixed cropping systems or as intermediate crop, for example ley. Its impact on yield depend on climatic, soil and agricultural conditions, however, "*the residual effect of legumes on yields of subsequent cereals can be equivalent to 20-123 kg mineral N fertiliser ha*$^{-1}$ (Grenz/Sauerborn 2007:59)".

Mixed cropping can increase yield, depending on the crop varieties and the implementation and management of the respective mixed cropping system. One specific form of mixed cropping systems is the agroforestry system, which is partly promoted for sustainable farming in the tropics. Advantages with regard to yield increase can arise from the shadowing and wind breaking effect of trees for smaller field crops, addition of SOM from litter and "pumping-up" of nutrients from lower soil horizons through deeper rooting systems (Traeger 1995). Problems might occur through competition of trees and other crops for light, water and nutrients (as in mixed cropping systems in general). A specific form of agroforestry is the inclusion of woody legumes in the farming system. Zech (1999) makes a distinction between two forms of agroforestry systems in the

biofuels, alternatives could be promoted (e.g. other sources of regenerative energies, secondary instead of primary biofuels) and general reduction of fuel use, e.g. through specific taxes in the transport sector could be enhanced. These are just few examples out of a variety of possibilities on different levels and scale for lowering the pressure on arable land and agriculture outside the agro-eco-system itself.

tropics: (a) Planting of fast-growing trees in the fallow period for improvement of general soil properties, and (b) simultaneous cultivation of annual and perennial crops.

In the latter category, alley-cropping[39] is a specific form of agroforestry, where the fertilizing effect of certain varieties of (leguminous) trees are used for increased accumulation of SOM and soil fertility (see Lehmann/Zech 1999, Traeger 1995): Leguminous trees (e. g. Glyricidia sepium, Leucaena leucocephala) are planted in rows and pruned as hedges. The space in between is used for annual crops, that profit from enhanced nutrient availability through N-fixation, additionally increased through litter and pruning residues. However, competition for light and water as well as high work demand is a disadvantage of such systems (Lehmann/Zech 1999). The success of alley-cropping systems highly depends on the respective management. Lehmann/Zech (1999:52) conclude that - as in all agroforestry systems - case-based decisions on (a) the agroforestry system design, (b) the management of the site and (c) the selection of species is necessary for an expected positive impact on yield.

Glaser (2007) offers insight in recent research on the so called *terra preta* soils. These black soils, initially found in the Amazonian rainforest, have high content of organic matter. This is rather atypical for soils in the humid tropics what makes them comparatively fertile and favourable for agricultural production. Their genesis is not yet reconstructed completely. Scientists offer different possible explanations for the increased accumulation of black carbon in these soils: High content of human or animal excrements, organic waste, terrestrial or aquatic biomass and others. There is rising consensus that the artificial generation of similar black soils[40] (*terra preta nova*) could contribute to an increasing, sustainable agricultural production in the humid tropics and thus to the reduction of food insecurity worldwide.

With regard to climate change, sound and locally adapted agriculture has a large adaptation as well as mitigation potential in the humid tropics. In general, the conversion of farming systems worldwide to organic agriculture is highly recommended in terms of climate change adaptation and mitigation, with positive side effects on related factors, such as food security improvement and poverty reduction. The basis in order to balance the predicted negative effects of climate change on agriculture and food security is early adaptation. Possibilities for adaptation on farm-level are manifold (see

[39] In Makrugbeh, the Sierra-Leonean NGO MADAM (Mankind's Activities for Development, Accreditation Movement) implemented a project that included the introduction of alley-cropping with the objective to increase soil fertility in the long run. As the project started in 2010 no expressive evaluation results are available so far.

[40] In other literature, this phenomenon is referred to as bio-char.

CGIAR 2009:18ff.) and depend on regional characteristics. Respective measures often synergize with mitigation of GHG emissions: Mitigation can sometimes be achieved simultaneously with adaptation measures, if these focus on ecological sustainability in general. Examples are (CGIAR 2009:40ff.): Enhancing the carbon content in soils through methods like non-tillage, mulching, cover cropping (extensive farming methods, non-technological); careful fertilize use and carbon sequestration, e.g. through agro-forestry systems; and additionally providing incentives for protection of forests and reduction of deforestation and other lands with high carbon content (wetlands, swamps, mangroves).

Further synergies are imaginable between measures of mitigating climate change on farm-level and the general protection of natural eco-systems and biodiversity (The World Bank 2010:137ff.). In general, we humans rely in different respect on natural eco-systems. Their resilience to stress is dependent on the status of its inherent biodiversity. Intact eco-systems with balanced biodiversity have several functions for human livelihoods. The UN differentiate between providing (water, resources, food), regulating (climate, health), supporting (nutrient and other matter cycles), cultural (aesthetic and recreational) and conservative (biodiversity protection) functions of eco-systems. Western African coastal areas and rainforest areas are defined as hotspots of biodiversity. But - as many others - they are endangered by global mankind and environmental changes leading to land degradation and desertification processes. It is necessary to protect eco-systems in order to benefit from their functions.

The global climate regime is working on (financial) incentives to protect carbon sinks and to avoid deforestation. One example is the programme “Reducing Emissions from Deforestation and forest Degradation” (REDD), introduced by the UNFCCC. It includes that countries, destroying their forest resources, have to pay compensation, whereas projects in favour of protection of natural carbon sinks are being supported finacnially. This mechanism should also take into account the changes in GHG emissions through land-use change, e.g. if valuable (primary) natural eco-systems are destroyed and replaced by unsustainable cash crop plantations that might be described as carbon sinks. As different players have different interest in this regard, a global binding agreement about REDD (or its expansion to REDD plus, including sustainable forest management or conservation and forest carbon stocks) is difficult to agree on (The World Bank 2010:165).

Concluding, sustainable farming in the humid tropics – as in any other eco-zone – has to be adapted to specific local conditions. The limiting factors with regard to soil fertility need to be considered, but several studies offer insight in possible adaptation measures and techniques. As rural households in the humid tropics are vulnerable to certain climate change impacts as well as food insecurity based on rather high poverty, adaptive measures and sound sustainable farming could contribute to the improvement of the general livelihood situation in this region. Furthermore, through several synergetic mitigation effects, sustainable farming can even contribute to minimizing the anthropogenic induced greenhouse effect. Positive side-effects are possible with regard to biodiversity protection.

6.2 Sustainability as cross-sector and multi-level approach

In this section, the previous findings are expanded on broader thematic and spatial scale: The discussions about the results from the case study analysis and the previous chapter focus on the potentials of land and agriculture for sustainable development, especially in the humid tropics. However, agriculture is just one – none the less crucial – factor in the complex system of global change. Therefore, ecological, social and economic sound improvements in other sectors and policies are inevitable for the creation of a sustainable global human livelihood. Scientists as well as experts from civil society try to develop measures and tools for equalizing global imbalances.

With regard to climate change, the principle of *common but differentiated responsibilities* needs to be taken into further account. Several possibilities of knowledge transfer as well as financial compensation from the main causers of the greenhouse effect to the ones that are most vulnerable and less capable of adapting to climate change have been developed. But there is still need for stronger commitments to a fair and sustainable approach as well as improvement in monitoring and evaluation of such projects. During the annual Conference of the Parties (COP) under organizational management of UNFCCC, possibilities of global mechanisms for financial incentives and compensation are developed and discussed. The existing tools and mechanisms of balancing the inequality in climate change need to be expanded and revised. The inequality between the ones who cause and the ones who suffer most needs to be bridged in a multilevel and multi-sector way. Financial compensation is insufficient. Adopted agronomic practices need to be linked to global carbon market for financial incentives and hence need to be discussed on global level. The value of the environment

and the agricultural sector for carbon storage and other eco-system functions need to be acknowledged more in the global climate regime, especially with regard to political decision making.

However, the institution of the COP is criticised as not being successful due to the diversity of the actors' positions (civil society, research institutions, governmental bodies) and the assignment to go though a immensity of topics (adaptation, mitigation, financial mechanisms, continuation of the Kyoto Protocol etc.) in a rather short period of time. Therefore, the discussions in the global climate regime often end in block building without common consensus and thus without final, binding agreements.

This complex global climate regime is furthermore overlapping with other policies, such as environmental protection, agriculture, world trade and global economy and development cooperation. This complexity makes the approach to agree on binding treaties in the global climate regime even more difficult, as these might interfere with other, already existing international guidelines and decrees (e.g. trading laws).

Cross-sector approaches are inevitable for embracing the complexity of global change processes. With this respect, Schneider (2009) argues that adaptation of agriculture to climatic changes is not enough in order to combat global hunger. Structural causes of food insecurity and poverty have to be overcome, amongst them unequal terms of trade, non-adequate representation of small scale farming and rural areas in (global) politics, as well as deficient education and health care systems. In this regard, he criticises the EU agrarian export subventions as well as the increasing competition between biofuel production and food production over scarce arable land. According to CGIAR (2009:41), the production of biofuels can provide new sources of income and energy for rural livelihoods. Nevertheless, the increasing demand in biofuels is leading to an increase in prices for several food crops[41] and is thus a major factor of global food price destabilization. Further negative impact on food price development arises from climate change (Welthungerhilfe et. al. 2011:25f.): Impacts of changes in atmospheric conditions and secondary impacts on agriculture lead to yield decline and uncertainties in yield predictions. Depending on the underlying climate scenario, rice price increases between 20 and 30 percent are expected till 2050. Even more severe will be changes on the maize price, where increase up to 50 percent is predicted. In the latest report on the

[41] Several agricultural products, usually consumed as food can be processed to bio-ethanol (e.g. sugar cane, maize, rape). The competition between food production and biofuels production is consequently about arable land as well as about the farming products themselves. As exception, jatropha, a non-edible plant that is adapted to relatively dry conditions, is often recommended highly in order to prevent such competition.

Global Hunger Index (GHI), the sensitivity of food price developments and its possibly severe impacts on global food security was highlighted: "*In addition to their economic, social and political impacts, food price spikes and excessive volatility worsen the problem of hunger by increasing poverty* (Welthungerhilfe et. al. 2011:21)."

Problems might also arise regarding the financing of projects dealing with global changes: Newly evolving financing mechanisms compete with already existing funds for development cooperation and disaster relief. Especially with regard to vulnerability to climate change and food insecurity, it is often not easy to identify if a certain threat or stress should be linked to climate change adaptation or mitigation or rather "conventional" development cooperation respectively disaster relief. The time delay due to identifying key responsibilities and most appropriate funding might finally affect the project negatively.

Policies with regard to reducing vulnerability to food insecurity in times of climate change need to be cross-sector and multi-level (Downing 2002:372f.). An interdisciplinary, holistic concept for global sustainable development is offered by Sachs and Santarius (2008): Experts from the Heinrich Böll Foundation, MISEREOR and the Wuppertal Institute for Climate, Environment and Energy together with scientists and civil activists from all around the world created a set of solutions for crucial problems and challenges in farming and agricultural trade. They plead for a better acceptance and implementation of human rights, the acknowledgement of the multifunctional character of agriculture, a better protection of the environment, and extraterritorial responsibility and fairness in global politics and economics. According to Sachs and Santarius (2008:26ff.) acknowledgement and implementation of these principles could solve crucial global problems like existing and enhancing asymmetries in trade and global decision making; and imbalance in power in favour of economically strong players with consequently fading out of ecological factors.

Growing coherence on the level of global policies and politics concerning climate change and environmental protection as well as in international trade and cooperation is inevitable. Vulnerability and sustainability research in general and specific case studies on local scale can contribute to a better understanding of global change processes and thus broaden the information basis for policy development and decision making.

7. Conclusion

A changing world is challenging: Global alterations in the ecological, economic and social face of our earth are affecting people and livelihoods on local scale. Regional patterns of consumption, production and lifestyle have reverse effect on the global level. The human-environmental interdependencies of global change are discussed in this thesis. The global-local linkages are acknowledged by putting the content in a sand-clock shape:

By introducing the problem statement at the beginning, the broad issue of global change (in spatial and thematic dimension) and the need for sustainable development is presented. Step by step, single thematic aspects and regional specifics were highlighted more and more: In the thematic dimension the role of land and finally agriculture was analysed with regard to food security and climate change; On spatial scale, the focus was drawn more explicitly to the eco-zone of the humid tropics and finally to Sierra Leone and the case study area. After analysing the vulnerability and sustainability situation of rural poor households in Makrugbeh in Northern Sierra Leone, the perspective broadened again. Key results and case-based recommendations are deduced back on broad and global scale: In the last chapter, the potentials and challenge of sustainable agriculture in the humid tropics and the need for cross-sector and multi-level approaches for global sustainable development are discussed.

The findings of the different sections are summed up in more detail in the following:

Global change is a complex system of interdependent processes. Three components can be identified: Global environmental change, globalization and global mankind change. These overlap partly with each other and are characterized by human-environmental linkages. Land and the way how it is being used plays a central role in global change, especially with regard to climate change and food security. Agricultural land-use and climate change stand in reciprocal relation: On the one hand, agricultural performance and therefore food security is highly dependent on climatic conditions. On the other hand, the farming sector is contributing to the global greenhouse effect through specific agronomic practices. Based on these linkages, rural poor households are especially vulnerable to climate change and food insecurity. For reducing such vulnerabilities, sustainable agriculture is inevitable.

The vulnerability to climate change and food insecurity can be assessed based on different scientific approaches. After discussing the central features of natural and social science based models, an integrated Vulnerability and Sustainability Assessment

(VASA) framework was developed. The VASA model includes central features of an integrated vulnerability research in combination with aspects from the Sustainable Livelihoods Approach: The vulnerability on farm-level consists of three central factors: (a) The baseline vulnerability to food security, (b) the risk exposure to climate change and (c) the coping and adaptation capacity. The correlation of these factors with the farm-inherent sustainability is acknowledged.

The research framework of VASA was applied in Makrugbeh, in the North of Sierra Leone. For a holistic assessment of the status of vulnerability and sustainability on farm-level, a twofold method and data triangulation was carried out: A set of different methods was applied, including a standardized questionnaire, three tools of Participatory Rural Appraisal (focus group discussion, seasonal calendar and pair wise ranking) and the sustainability analysis RISE. This triangulation combines quantitative and qualitative with participatory and non-participatory methods. The empirical findings are cross-checked with data from secondary sources during the analysis.

The case aims and objectives of the case study analysis were:

- Indicating the crucial role of agriculture within global change processes on local scale
- Describing one of the most vulnerable regions with regard to climate change and food insecurity
- Showing the correlation of vulnerability with sustainability on farm level
- Giving insight in specific challenges and potentials for sustainable rural development on farm and household level

The results show a critical picture of the rural livelihoods in Makrugbeh: The baseline vulnerability of the farming households is very high. The reasons are manifold and partly related to the long-term impacts of the civil war in the 1990ies. The households are affected by high poverty, periodical times of food scarcity and an inadequate system of education and health care. The dependency on agriculture as basically single source of food, income and other commodities is very critical. The village is exposed to a rather high risk to climate change. The farmers are already experiencing changes in precipitation patterns that affect their farming activities negatively. Climate scenarios predict further hazards and stress for the agricultural sector in Northern Sierra Leone in the future. The effect can be devastating for Makrugbeh, as the coping and adaptation capacities of the households are very low. This is mainly related to the critical status of sustainability on farm-level: The economic sustainability is in a problematic condition

due to the lack of adequate household budget planning and farm management. Social indicators such as working conditions and quality of life range in the critical category. Key challenging factor for the ecological sustainability on farm level is the soil fertility. The conditions of the eco-zone of the humid tropics with summer rains limit the agronomic potentials.

In general, the farming households in Makrugbeh are faced by a high vulnerability to climate change and food insecurity, partly related to the critical status of sustainability on farm-level. Increasing demand in agricultural products and arable land for other purposes put pressure on farmers and natural resources. It is inevitable to adapt farming practices to local specific conditions in a sustainable manner.

The potential measures for reducing vulnerability to climate change and food insecurity through improvement of the status of sustainability on farm-level are manifold. Different alterations in agronomic practices are imaginable. Also, improvement of farm management and enhancement of the economic viability through the inclusion of secondary income sources are imaginable. Due to the complexity of global change processes and global-local linkages, the inclusion of a broader framework is inevitable: Political and socio-economic changes and decisions on national and international scale influence rural livelihoods. Therefore, sustainable development needs to be considered as cross-sector and multi-level approach.

Concluding, global change research is in need for an integrated approach in order to embrace the issue holistically. Specific case study analyses are inevitable for case based insight in specific conditions and reciprocal local-global linkages. The presented thesis contributes to this approach in different ways: The crucial role of agriculture in global change is indicated; The vulnerability structures of rural poor households in Northern Sierra Leone are assessed; And the potentials of sustainable agriculture for climate change mitigation and adaptation and for food security improvement are presented on local and global scale.

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Appendix

I. List of participating farmers

Nr.	Nachname, Vorname	Special role or position	Participation in following methods				
			Standardized questionnaire	Participatory Rural Appraisal			RISE
				Focus Group Discussion	Seasonal Calendar	Pair-wise ranking	
1	Bangura, Fatmata		x				
2	Bangura, Kadiatu		x				
3	Bangura, Mohamed		x				
4	Fornah, Daniel A.	Town Secretary	x	x	x	x	x
5	Fornah, Isatu M.	Town Chairlady	x				
6	Gbla, Alpha		x				
7	Gbla, Amidu		x				
8	Kabbia, Mohamed	Town Youth Leader		x	x	x	
9	Kamara, Ali		x				
10	Kamara, Ibrahim		x				
11	Kamara, John	Section Secretary	x				
12	Kargbo, Henry	Section Chief	x	x	x	x	
13	Sankoh, Ali			x	x	x	
14	Sesay, Alimamy	Rep. of Town Chairlady		x	x	x	
15	Sesay, Hawa		x				
16	Sesay, Osman		x				
17	Thollie, Ibrahim		x				
18	Turay, Ali	Section Youth Leader	x	x	x	x	x
19	Turay, Hawa	Chairlady Assistant					x
20	Turay, Isatu	Town Headwoman		x	x	x	

II: Standardized questionnaire

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DEPARTMENT OF GEOGRAPHY

Questionnaire for field research for diploma thesis on vulnerability and sustainability on farm-level in Makrugbeh, Sierra Leone

Date of questioning: _____

1. HOUSEHOLD-RELATED INFORMATION

1.1 Name of farmer:

1.2 Sex: □ m □ f

1.3 Age: □ up to 20 □ 21 - 30 □ 31 - 40
□ 41 - 50 □ above 50

1.4 Marital status: □ married □ single □ divorced □ widowed

1.5 Education: □ Primary School □ Secondary School □ Further education
□ Training/FFS (specify):

1.5 Household structure:

	Relation					**Sex**		**Age**
	Wife/ Husband	Child	Parent	Brother/ Sister	Other	m	f	
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								

1.6 Any non farm-related income?

□ yes □ no

If yes, please specify:

2. FARM-RELATED INFORMATION

2.1 Farmland:

Component *(e.g. swamp, forest)*	**Size** *(in acres)*	**Use**		
		Crop farming	Animal husbandry	Fallow
Total size:				

2.2 Description of farming practice: Shifting cultivations?

□ yes □ no

If yes: Length of fallow period (years):

If yes: Is the applied period of time sufficient for soil nutrient rehabilitation?

□ yes □ no

2.3 Planted crops:

Crop	**Way of cropping**		**Use**		
	Mixed	Separate	Consumption	Sale	Other

2.4 Significant yield loss experienced within the last 3 years?

□ yes □ no

If yes: Reason(s): □ pests □ diseases

□ water shortage/no rains □ heavy rains/storm/flooding

□ other (specify):

2.5 Animal husbandry:

Livestock	**Quantity**	**Use**		
		Consumption	Sale	Other

Thank you for participating!