DIPLOMARBEIT

Titel der Diplomarbeit

„Consequences of climate change
on resilience of the food production system in
Marchfeld, Vienna Region“

Verfasserin

Katja Bohländer

angestrebter akademischer Grad

Magistra der Naturwissenschaften (Mag.rer.nat.)

Wien, 2012

Studienkennzahl lt. Studienblatt:	A 474
Studienrichtung lt. Studienblatt:	Diplomstudium Ernährungswissenschaften
Betreuerin / Betreuer:	Dr. Alexander G. Haslberger

Acknowledgement

First of all I would like to thank my supervisor Dr. Alexander G Haslberger, who announced this thesis subject and initiated the interdisciplinary scientific research group “Climate Change and Rural Development”. For the extraordinary opportunity to participate in this project, the good atmosphere during research and for all gained experiences I am very grateful. I also want to thank Dr. Reinhard Paulesich, who provided me with important inputs.

Various institutions supported this thesis with expert knowledge and prepared data sets. In the course of this engagement, my special thanks receive DI Walter Mittendorfer (Department of veterinary issues and food controlling, Lower Austria), Mag. Martina Dötzl (Statistics Austria), DI Klaus Wagner (Federal Institute of Agricultural Economics), Ao.Univ.Prof. DI. Dr. Guenter Breuer (BOKU), Gerhard Eigner (Agrarmarkt Austria) and of course all farmers in Marchfeld which provided me with expert knowledge during study time.

Very special thanks belong to my family and friends, for their confidence and mental support. And finally, especially for the last months, I am particularly grateful to my partner DI Dr. Gerald Kalt, who served me numerous incentives to ultimately complete this final year’s project and enriches my life in all kinds of ways. Thank you!

Table of contents

List of Figures

List of Tables

List of Abbreviations

AEZ-BLS .... Agro-Ecological Zoning – Basic Linked System
AGES .... Österreichische Agentur für Gesundheit und Ernährungssicherheit
AMA .... Agrarmarkt Austria
AMS .... Arbeitsmarkt Service
AOGCM .... Atmosphere-Ocean General Circulation Models
BOKU .... Universität für Bodenkultur, Wien (University of Applied Life Sciences, Vienna)
BMLFUW .... Bundesministerium für Land- und Forstwirtschaft, Umwelt- und Wasserwirtschaft
CAWMA .... Comprehensive Assessment of Water Management in Agriculture
EASEY .... Ecological and Social Efficiency
FAO .... Food and Agriculture Organization of the UN
GCM .... General Circulation Model
GEO .... Global Environmental Outlook
GAEZ .... Global Agro-Ecological Zoning
IAASTD .... International Assessment of Agricultural Science and Technology Development
IFOAM .... International Federation of Organic Agriculture Movement
IIASA .... International Institute for Applied System Analysis
INVEKOS .... Integriertes Verwaltungs- und Kontrollsystem
IPCC .... Intergovernmental Panel on Climate Change
LBG .... LBG Austria GmbH
MA .... Millennium Ecosystem Assessment
NGO .... Non Governmental Organization
ÖPUL .... Österreichisches Programm zur Förderung einer umweltgerechten, extensiven und den natürlichen Lebensraum schützenden Landwirtschaft

SAFA .... Sustainability Assessment of Food and Agriculture Systems

SAfMA...................... Southern Africa Sub-Global Assessment

SRES .... Special Report on Emission Scenarios

WKO .... Wirtschaftskammer Österreich

UNEP....................... United Nations Environmental Programme

UNFCCC.................. United Nations Framework Convention on Climate Change

ZAMG .... Zentralanstalt für Meteorologie und Geodynamik

1 Introduction

Climate change, land-use change, species extinction, urbanization, biodiversity loss and deforestation are human-induced or at least human-influenced changes of the physical and biogeochemical environment and together with naturally occurring changes are classified as “global environmental change” (see INGRAM et al, 2010, 8).

Broad public awareness of global environmental change and its consequences for human health started with the United Nations Conference on Human Environment in Stockholm, Sweden, in 1972, which resulted in the foundation of the United Nations Environmental Programme and consequently lead to further conferences and several conventions such as the Convention on Biological Diversity or the United Nations Framework Convention on Climate Change UNFCCC supported by international scientific assessments such as the Millennium Ecosystem Assessment or the Intergovernmental Panel on Climate Change (WELLS et al, 2006).

Looking closely at global environmental issues, many manifestations are not only a health problem but affect food security in particular. For instance ongoing biodiversity degradation and loss especially through overexploitation of wild species threaten local food provision, compromise income and employment. In 2010 every second individual lives in cities and world population grows - reaching 7 billion in 2011 - ,fostering intensification of agriculture, causing groundwater depletion and soil salinity with severe consequences for food security and human health. Further, global livestock production is responsible for about 8 per cent of global freshwater consumption and is a major driver of water pollution and eutrophication, leading to disruption of nutrient cycling, freshwater decline and food insecurity (UNEP, 2012).

Impacts of climate change on world food system and thus food security are documented and illustrated by numerous assessment models such as the "Global Environmental Outlook", the "Millennium Ecosystem Assessment", the "Intergovernmental Panel on Climate Change" and the "AEZ-BLS" by IIASA/FAO. However, as summarized in a recent published review of assessments dealing with food security and global environmental change, most scientific assessments investigate just a few aspects of the whole food system by a small set of indicators, just addressing a small amount of decision makers (INGRAM et al, 2010). Moreover, data pool at sub-national level tends to be fragmented or is often discontinuous. In addition, different classifications and methodologies result in different outcomes and complicate comparability of data in time and space-boundaries. For instance, estimates of global urban area previously derived from global urban population maps are many times over estimates derived from satellite (UNEP, 2012, 215ff). In times of ongoing global environmental change threatening human existence, there is a need for scientific environmental assessments and thus integrated, local analysis of complex social-ecological interactions affecting food security, to support decision-making at local scale and at regular intervals, because adaptation finally takes place at local-level such as within households and communities (INGRAM et al, 2010, 117).

Beneath lack of successful integrative, consecutive assessments of global environmental change and food security, actual situation of climate change mitigating programs is alarming. On the one hand, the first commitment period of the Kyoto Protocol ends in 2012 and yet no further international framework is ratified. On the other hand, in contrast to Austria´s agreement to reduce greenhouse gas emissions by 13% below 1990 levels, in 2010 Austria´s greenhouse gas emissions increased by 8.2% compared to the base year 1990 and seems - together with numerous other developed countries - not to fulfil its Kyoto target till the end of 2012 (ANDERL et al, 2012, 16).

1.1 Aim of the study

Although some projects addressing environmental issues of the production area Marchfeld have been already carried out, comprehensive studies about this region are still missing. The aim of this study is to form a basis to analyse resilience of the food production system near Vienna, with special emphasis on climate change and its impact on agricultural production and food system next to Vienna. There is a need to employ all relevant data series into one single model, because profound data is widely scattered to various institutions (e.g.: BOKU, BMLFUW, AGES, AMA, AMS, WKO, ZAMG) and organisations in Austria. It will ease the assessment of environmental issues in this region and will allow communities to make appropriate choices with the context of this region.

Another purpose of this thesis is to find out if design of the EASEY model, which was originally developed for a sustainability performance rating of prime market quoted enterprises at the Vienna stock exchange (PAULESICH et al, 2006a,8), allows resilience and sustainability analysis of whole regions famous for its specific area of production like Marchfeld and its enormous agricultural area.

This thesis is concerned with climate change at local level, technically speaking with consequences of climate change on resilience of food system in the production area Marchfeld, well-known for crop-production such as cereals, root crops and vegetables to ensure food consumption of Vienna Region, and its low amount of precipitation (FREYER et al, 2010,19). It is an approach to investigate food security by means of an integrative model, the EASEY model. It is an approach to apply appropriate indicators, to address various decision makers with comprehensible outcomes while weighting interests of economy, society and environment equally to support sustainable development (PAULESICH et al, 2006b, 27).

Within this thesis, the applicability of the EASEY model, the Ecological And Social EfficiencY model, not for one single enterprise but for the whole food production area Marchfeld shall be examined, appropriate indicators for sustainable development collected, an indicator set for performance along the food value chain developed as well as impacts of disturbances such as changing climatic conditions on local food production and thus food security in a broad way assessed.

2 Literature overview

Online search for established international scientific assessments dealing with climate change and its consequences for food system activities respectively food security outcomes in general and not just focused on one specific area and its drivers of ecosystem´s change, resulted in a handful of important approaches such as the Millennium Ecosystem Assessment (MA), the AEZ-BLS simulations design by FAO and IIASA, the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment, the International Assessment of Agricultural Science and Technology Development (IAASTD) and, in consideration of climatic conditions in the study area Marchfeld, last but not least, the Comprehensive Assessment of Water Management in Agriculture (CAWMA). Finally, the Millennium Ecosystem Assessment and AEZ-BLS integrated ecological-economic analysis of climate change and the world food system have distinguished themselves by number of conducted assessments and reasonable traceability of data collection and approach. The following description gives an overview of the assessment approach and summarizes main output, providing the basis to fit an integrative model such as the EASEY to social-ecological systems with focus on climate change.

2.1 Millennium Ecosystem Assessment

History

During the 1990s scientists and policy makers identified a need for effective integrative assessment processes on climate, biodiversity and land-use to bring to life global agreements like the Convention of Biological Diversity and the Convention to Combat Desertification (WELLS et al, 2006, 1).

Scope

Between 2001 and 2005, as an international, multi-scale, $25 million assessment, conducted by the United Nations Environment Programme, the MA was carried out by about 1400 experts from 95 countries and various disciplines addressing not only scientists from different fields and nationality, but international organisations such as the United Nations Environmental Programme, the World Bank, governments, NGOs, the corporate sector and local groups (WELLS et al, 2006).

Objective

Its main tasks were to investigate at global- and sub-global-scales current state, trends and prospects of ecosystems, ecosystem services and consequences of change for human well-being, publishing scientific assessment reports as a basis for action to underline sustainable use of ecosystems and its benefits for human well-being (HASSAN et al, 2005).

Methodological framework, dataset and other assessment tools

The MA conceptual framework deals with the dynamic interactions between human activities and ecosystems, whereby changes can occur at various scales according to local, national and international decision-making, provoked by direct respectively indirect driving forces (HASSAN et al, 2005). A driving force respectively driver in this context is defined as “any natural or human-induced factor that directly or indirectly causes a change in an ecosystem” (NELSON et al., 2005, 74). Changes in ecosystems can be described with regard to ecosystem services which have apparent value to human well-being. The MA conceptual framework differentiates ecosystem services in regulating, cultural, supporting and provisioning services, the latter including food or freshwater (HASSAN et al, 2005).

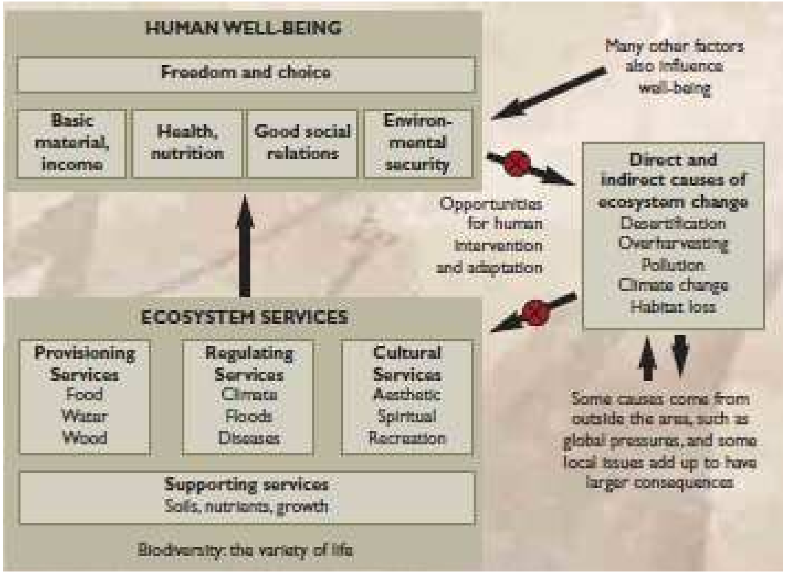


Figure 1. Conceptual framework of the Millennium Ecosystem Assessment
Source: BIGGS et al, 2004

The MA combines peer-reviewed datasets with expert-knowledge from the private sector, empirical values from practitioners, local communities and indigenous people. It pointed out social benefit and dependency of human well-being from biodiversity and intact ecosystems and evaluated already adopted measures to mitigate global change, explained interactions between diverse systems and specific drivers via integrated models, developed possible scenarios for future trends of ecosystem drivers, ecosystem services and human well-being and elaborated possible sustainable opportunities for action to enhance human well-being with the intention to protect ecosystems (HASSAN et al, 2005; WELLS et al., 2006).

Within the MA global reports of current state and trends of ecosystem services, chapter 8, 13 and 26 are dedicated to food and climate (WOOD et al, 2005; HOUSE et al, 2005; CASSMAN et al, 2005).

Especially chapter 8 deals with the assessment of the provisioning service food with emphasis on food demand and supply and its direct respectively indirect drivers of change. Condition of the past 50 years as well as current situation and trends were examined and separately assessed for developing and industrial countries. Thereby, impacts on food provision change of every single driver such as population growth and structure or international trade regimes and regulations were classified by the categories: low, medium and high. With regard to food system components, in chapter 8, the MA mentions solely parts of the whole food chain, first of all agricultural production and consumption, leaving out trends and current state of food industry, retailing and waste production as well as packaging. A review of scientific literature to the topics climate data, change in food quality and yield result in the observation that climate variability and long-term climate change were categorized as direct drivers of food provision, whereby relevance has been low or moderate but was calculated to rise till 2015 (WOOD et al, 2005).

Impacts of ecosystems on climate as a regulatory ecosystem service have been analyzed in chapter 13 considering atmospheric constituents such as methane, other greenhouse gases and consequences for human well-being – comprising health, basics to enhance quality of life and social justice such as access to resources (HOUSE et al, 2005). In spite of ecosystem assessment, chapter 26 of MA Current State and Trends deals with cultivated systems and its drivers of change including climate change with focus on complex interrelationships between different driving forces and agro-ecosystems (CASSMAN et al, 2005). Relevant conclusions made by the MA investigating group comprises that modern food production is the largest consumer of ecosystems and its services and is threatening biodiversity as well as ecosystems ability to cope with disturbances. In addition, according to the MA, climate is an important unmanageable part of the earth system which modifies food production and further challenges attempts to assess particular effects on food security apart from other drivers of change (WOOD et al, 2005).

The MA approach also covers sub-global assessments such as the Southern African Millennium Ecosystem Assessment (SAfMA) integrating eight assessments at three scales embedded into one another: one regional, two basin and five local scale assessments. Thereby SAfMA investigated at all scales condition and trend in demand and supply of essential ecosystem services namely water, food and biodiversity as well as services of special interest within the region (BIGGS et al, 2004). National databases from governmental institutions and land cover maps were collected at different scales and sometimes jointed to one single scale to assess ecosystems condition. The local assessments focused on data concerning indigenous knowledge and information on cultural practises especially on response to changing surrounding environment, collecting information on primary concern of decision-makers and local communities, which decided the focus of further assessment process. Human use of ecosystem services was assessed by summaries of available literature, household surveys, through expert interviews and Participatory Rural Appraisal group sessions. Finally, status of ecosystem services were measured via interpreting satellite images and trends by means of available social-ecological system models such as the International Water Management Institute´s model PODIUM (BOHENSKY et al, 2004). Additionally, SAfMA evaluated the performance of national and regional management which has been identified as the crucial factor influencing development of southern Africa over the next 30 years. On the analogy of two scenario archetypes “Policy Reform” and “Local Resources” SAfMA developed the regional-scale scenarios African Patchwork 2030 and African Partnership by extracting information from available regional scenarios and calculating plausible effects on ecosystems, ecosystem services and human well-being while using the MA Conceptual Framework to improve understanding of ecosystem functioning. Main focus along the food system was on food supply and demand measured by mean annual production per capita or recommended dietary allowance in calorie per capita per day. Climate and environmental stressors, poverty, high food prizes and social political unrest belonged to main drivers of food insecurity derived from a synthesis of 49 local-level case studies in Southern Africa (BIGGS et al, 2004).

Main achievements of the Millennium Ecosystem Assessment included high quality reports on current state and trends of ecosystems and human well-being being available online for free and an innovative Conceptual Framework to explore trade-offs between ecosystem services and human well-being. Further, the MA provides a scientific basis for other activities made by the Convention on Biodiversity and the Ramsar Convention on Wetlands, creating a global community for additional ecosystem assessments consistent of scientists, intergovernmental institutions, private sector and local communities. On the other side, some weaknesses must be mentioned such as its low impact on policy formulation due to the fact that crucial policy makers were not part of the MA process. Further, communication and outreach after availability of major reports were marginal as a result of insufficient financial resources. The MA was not able to create tools, methods and models that can simply be applied by decision-makers. Last but not least, time and resources for sub-global assessments were rated as insufficient (WELLS et al, 2006).

2.2 AEZ-BLS integrated ecological-economic analysis of climate change and the world food system

History

1978 the UN Food and Agriculture Organization (FAO) together with the International Institute for Applied Systems Analysis (IIASA) started to analyze land productivity and resource management under particular conditions to assess the world food system with regard to current and future global change affecting food security (FAO, 2012a).

Scope

The Global Agro-ecological assessment is a multi-scale, integrated ecological, social and economic assessment conducted by IIASA and FAO, whose outcomes are currently updated and published in FAO´s global perspective studies like "World agriculture: towards 2030/2050". The GAEZ addresses primarily policy makers, scientists and international institutions (FISCHER et al, 2002; FAO, 2006).

Objective

The GAEZ main task was to create an assessment tool to describe land resources to support management, monitoring and planning of available resources (FAO, 2012a).

Methodological framework, dataset, assessment tools

The AEZ-BLS approach combines outcome respectively tools of three different assessments:

- *Socio-Economic Scenarios* defined by the Intergovernmental Panel on Climate Change in its Special Report on Emissions (*SRES*)
- *Agro-Ecological Zoning* constructed by IIASA/FAO to analyse vulnerability of agro-ecosystems to climate change
- *Basic Linked System* by IIASA - assessing national respectively regional food systems considering the whole economy of the country/region with regard to production, consumption and trade. (FISCHER et al, 2005)

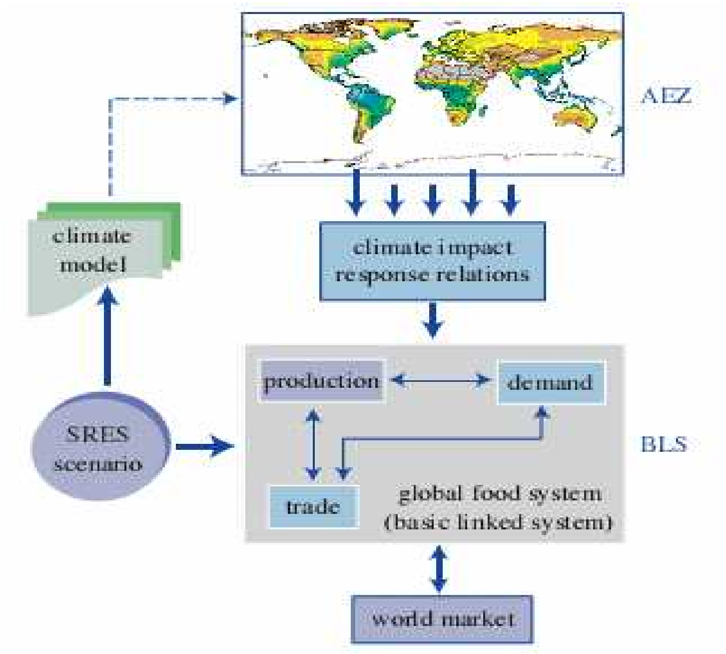


Figure 2. Graphic description of the AEZ-BLS modelling framework
Source: FISCHER et al., 2005

Generally speaking, the AEZ methodology offers a framework to build a spatial register and database of land properties - embedded in available climatic, soil typical conditions, including landform and present land cover derived from a global climate data set, encompassing average data from the 30-years normals (1961-1990) and annual data for the period 1901 – 1996, and for crop-productivity. Additionally, it incorporates information in relation to 11 aggregate land-cover classes deduced from 1km land cover data set of the Earth´s surface. This database supports assessment for defined management patterns with specific amount of inputs and fitness of plant cultivars under both rain-fed and irrigated production. In summary, the AEZ differentiate 154 crop, pasture and fodder Land Utilization Types (LUT) which are again divided into high, intermediate and low levels of input and management. All in all about 2.2 million grid-cells were fed with geo-referenced climate, soil and environment data. (FISCHER et al, 2002).

In the following, data from four General Circulation Models utilized for the IPCC SRES socio-economic scenarios A1FI, A1B, A2, B1 and B2 were adopted by the AEZ model. These IPCC SRES scenarios address important drivers such as technological, economic and demographic development leading to future emissions of all relevant greenhouse gases and sulphur and together with findings from AEZ database illustrate vulnerability of global food production to climate change (FISCHER et al, 2002).

Finally, combined findings are projected at the Basic Linked System model, which describes - in the broadest sense - agricultural policies and national food systems and therefore behaviour of diverse stakeholders such as producers, consumers and governments through calculation of net imports and exports of all economic activities for countries and country groups. Simulations with the BLZ result in several model indicators including market prices, production and consumption at global-scale, producer and retail prices, intermediate input use, gross domestic product, estimates of the number of people at risk of hunger, income parity and calorie consumption (FISCHER et al, 2002).

The AEZ-BLS model incorporates numerous climate and socio-economic data concerning development of global and national food systems. However, as Ericksen mentioned, the assessment focused on climate change impacts on crop production but neglect other processes of the food system such as processing and packaging (ERICKSEN, 2007). It is further questionable if economic performance - expected in diverse socio-economic SRES scenarios - represents plausible future economics and is not overestimated as criticized by Fischer. Another point of criticism is that the AEZ-BLS approach only assesses impacts of mean climate change, excluding possibility of extreme climatic events such as floods during scenario development (FISCHER et al, 2005). Anyway, the AEZ-BLS approach is still part of numerous programs which are based on this single modelling framework (SCHMIDHUBER and TUBIELLO, 2007, SOUSSANA et al, 2010).

Due to its nature to describe dynamics in complex systems and the ability to be successfully adjusted in diverse disciplines and contexts, more recent local assessments attempt to evaluate climate change and its consequences for social-ecological systems within the concept of resilience to find out vulnerability of system essentials (CABELL and OLEOFSE, 2012; SINGH et al 2012; EAKIN and WEHBE, 2009). Before advanced EASEY methodology, which is also based on resilience thinking, is introduced, it seems to be necessary to describe several system analytical tools and the current understanding of resilience theory of interlinked systems of people and ecosystem services they depend on.

2.3 Tools to describe managed resource systems

There exist several tools to describe and investigate dynamics and changes in managed resource systems. Following short characterization shall give an insight of what is significant for resilience and other concepts.

The concept of *transformability* focuses on the ability to build a completely new system, when the present system is undesirable, while looking from another point of view, the concept of *adaptability* deals with the power of the players to manage resources in this system (WALKER et al, 2006).

Next tool worth-mentioning and already part of resilience theory is the *adaptive cycle,* describing periods characterized by divergent degree of resilience, in which systems move along Figure-Eight Model (see HOLLING, 1987). Within this view and according to observed system changes there is a general agreement that human and natural systems are expected to be dynamic, not static. Changing functions and structures of the same system are segmented into four phases: the highly resilient, long-lasting growth phase (r) with plenty of resources to build up, followed by the conservation phase (K) consisting of complex, energy- and resource-intensive structures and curbed expansion, less flexible, less resilient and more vulnerable to perturbations. After a time system collapses abruptly and bound-up resources are set free as a consequence of ongoing perturbations, marking phase of release (Ω), paving the way for system reorganization (α) with similar to totally different functions (CARPENTER et al 2001, WALKER et al 2006).

The theory of *vulnerability* describes exposure to interruptions or exogenous stresses, focusing on components at risk and the capacity to assimilate (GALLOPIN, GC, 2006). Some scientists even recognize vulnerability as the flip side of resilience. Anyway all these concepts can be adapted to investigate dynamic systems and support decision-making processes but from a different point of view (FOLKE et al, 2002, ADGER 2000). However, the concept of resilience fits best for the subject area and is therefore elaborated in more detail.

2.4 The concept of resilience in literature

The concept of resilience originates in the 1960s and 1970s in the science of human development, where children who appeared to be “invulnerable” to adverse conditions were subject of debate. As theory and research proceeded, the term “invulnerable” was regarded to be too rigid and unchangeable and was substituted by the term “resilience”, derived from the Latin word “resilire” which means to bounce off respectively to rebound, changing the emphasis on different degrees of response options to undesirable circumstances (MASTEN and GEWIRTZ, 2006). In general, overcoming external stresses and negative impacts as a result of social, political and environmental change is subject to social resilience science, which examines the ability of communities and groups to manage change (ADGER, 2000; SHERRIEB et al, 2010; SINGH and TURNER, 2012). Factors such as the absence of economic health, incomplete information among social actors, inadequate institutional organisation, weakness in emergency preparedness and political instability contribute to a greater risk to external stresses. However, resilience of social systems is closely related to resilience of ecological systems because social resilience is dependent on natural resources and therefore on its environment (ADGER 2000; SINGH and TURNER, 2012).

Simultaneously to social sciences, the term *resilience* was introduced in ecological research. The most cited definition of ecological resilience by the Canadian ecologist CS Holling sights resilience as a "measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (HOLLING, 1973, 14). His definition relies on the overall area and the resistance of a population to disturbance, focusing on the persistence of populations and the probability to become extinct within the ecosystem. Within this concept, it is provided that subsistent systems are often exposed to disturbance and therefore in a dynamic but stable state, the so-called "basin of attraction" – a state in which the system tends to remain (GALLOPIN, 2006). More recent work describes resilience as a measure of distribution of functional roles of species and elements within or across system scales to remain organized within the regime. In this case important changes in ecosystem dynamics can be understood by analyzing its critical structure and key processes within and across scales while individual species can be replaced (WALKER et al 2006, SUNDSTROM et al, 2012).

Resilience in economics covers the ability to recover from, adapt to or prevent negative impacts of external economic shocks such as the financial crisis in 2008 and therefore refers to the capacity for continuous reconstruction. Resilient organizations are conscious of what is changing and want to find out how those changes are able to affect current success. They are working on alternatives before strategies are dying and are able to shift resources from neglected products to new ideas and programs (HAMEL and *VÄLINKANGAS,* 2003). In other words, economic resilience is used to describe the competence to recover quickly from market crisis, to withstand the effects of this crisis respectively to avoid it, but most importantly as Simmie and Martin (2010) reflected, is building resilience by enhancing adaptive capacity to external and internal shocks, to build capacity for ongoing reconstruction respectively "creative destruction" to stay innovative (SIMMIE and MARTIN, 2010).

Recent assessments of sustainable development focus simultaneously and equally on social and ecological systems for the simple reason that human and natural systems are closely related and human beings are part of nature. On that note, food systems too are interlinked with societies, politics, culture, economies and environment (ERICKSEN, 2008; CABELL and OELOFSE, 2012). According to this and to emphasize complexity of food systems, sustainable development should be measured on a broader concept, on its social-ecological resilience, defined as the capacity of linked social and ecological systems "to absorb recurrent disturbances for example hurricanes, (…) so as to retain essential structures, processes and feedbacks" (ADGER et al., 2005: 1036), while focus on economic resilience will directly be relevant for food production performance.

In terms of food system research, the aim of assessing resilience is to advise humans – in particular policy makers and local stakeholders - how to retain the system within a specific composition of states to keep on delivering required levels of ecosystem goods and services, how to prevent the system from turning into less desired compositions from which it is more tricky to recover from perturbations respectively how to increase food system´s capacity to manage change (LEBEL et al, 2006; CABELL and OELOFSE, 2012).

According to FAO´s food price index, food prices have been outstanding volatile since 2006 but for the most part remained above the levels as price rises just began, significantly taking part in increasing the number of hungry people (FAO, 2011a; FAO, 2011b). Returning back to global change and its linkage to food security, there is a pressing need for further understanding dynamic linkages between anthropogenic activities and the environment to enhance stakeholders´ capacity to enable food security as well as resource conservation. Actually, scientists from different fields have been dealing with modern food system´s sustainability and some already successfully within adjusted resilience assessments (CABELL and OELOFSE, 2012).

The theory of resilience presents a proper framework to analyze complex food systems in a changing world, helps to better understand dynamic interactions between human beings and their environment and provides models to strengthen people´s capacity to manage shocks and changes over time. However, from human well-being point of view, a resilient social-ecological system must not always be regarded as positive like in the case of desertification. Hence, it is a context dependent tool, which is not always easy to operationalize due to its metaphoric nature (BENNETT et al, 2005; DARNHOFER et al 2010; CABELL and OELOFSE, 2012). Next section is concerned with resilience metrics in food systems and gives an overview of resilient food system characteristics.

2.5 Resilient food systems in literature

Resilience theory can be operationalized in different ways as scientific literature verified with three different approaches at the core of research, namely I) total sum and frequency of change a system can tolerate and still retain similar controls on function and structure, II) the ability to learn and adapt to change and III) property of self-organisation (see CABELL and OLEOFSE, 2012)

Focusing primarily at persistence, a fundamental approach to conduct resilience assessments has been created by the Resilience Alliance (2010), which provides a stepwise guidance to build a conceptual model of the social-ecological-system of interest, to find potential thresholds representing a bridge between two alternative system states and supported decision making in how far phenomena contribute or reduce system resilience (RESILIENCE ALLIANCE, 2010). FAO developed an assessment, which is more focused on sustainability performance in the form of a rating to analyse production sites, which rests upon precise indicator-based methods. The so-called Sustainability Assessment of Food and Agriculture Systems (SAFA) by FAO provides transparent guidelines to method and principles for performing a sustainability assessment system, specifies basic sustainability categories, indicators to evaluate performance and lists minimum requirements for sustainability, looking at adaptive capacity of food production sites (FAO, 2012b). For the reason that agro-ecosystems are too complex to be measured in any precise ways, Bennett et al. (2005), Darnhofer et al. (2010) and Cabell and Oelofse (2012) present more general methods based on resilience surrogates, rules or behaviour-based indicators, which when identified suggest that agro-ecosystem can be classified as being resilient, highlighting ability to be socially self-organized. However, majority of assessments dealing with resilience prefer a mixed approach for evaluation: Koohafkan et al. (2011) favour to identify threshold sustainability indicators to evaluate sustainability of food systems (KOOHAFKAN et al, 2011). King (2008) compared perspectives of agro-ecosystem resilience such as engineering resilience or ecological resilience with popular alternative agro-ecosystem principles such as organic agriculture and evaluated contribution of these systems to particular perspectives (KING, 2008). On the contrary, Fletcher and Craig (2006) created a more complex approach, consisting of conceptual models and simulation models together building a dynamical system´s model producing quantitative results thereby determining performance of agro-ecosystem management (FLETCHER et al, 2006). Approaches seem to be totally different, reflecting the wide range of resilience thinking, norms and values of scientists. However, as Cabell and Oelofse (2012) already mentioned, most of the assessments started with an approach to identify key components of the social-ecological system and then investigate disturbances and uncertainty, in other words the resilience of what to what (CABELL and OELOFSE, 2012).

The following table shall point out comparability of indicator sets, constructed by FAO and the Norwegian scientists Cabell and Oleofse. Though indicator sets seem to be totally different, indicators can be linked to each other, which highlights the integrative character of these approaches.

Table 1. Comparison of SAFA indicator set with behaviour-based indicators developed by CABELL and OLEOFSE

Source: FAO, 2012b; CABELL and OLEOFSE, 2012

Performance and measure-based indicators (SAFA, FAO 2012)	Indicators for assessing agroecosystem resilience (CABELL and OELOFSE, 2012))											
	Socially self-organized	Ecologically self-regulated	Appropriately connected	Functional and response diversity	Spatial and temporal heterogeinity	Exposed to disturbance	Coupled with local natural capital	Reflective and shared learning	Globally autonomous and locally interdependent	Honors legacy	Builds human capital	Reasonably profitable
5.1 Governance structure						x	x	x	x		x	
5.2 Accountability							x	x	x			x
5.3 Participation	x		x	x		x	x	x	x	x	x	
5.4 Rule of law	x					x		x		x		x
5.5 Holistic management				x	x	x	x	x	x	x		x
5.6 Atmosphere		x					x	x		x		x
5.7 Freshwater		x					x	x		x		x
5.8 Land		x		x	x		x	x	x	x		x
5.9 Biodiversity		x	x	x	x	x	x	x		x		x
5.10 Materials and energy		x		x	x		x	x	x	x		x
5.11 Animal welfare	x	x					x	x		x		x
5.12 Investment			x	x	x		x	x	x			x
5.13 Vulnerability	x		x	x	x		x	x	x	x	x	x
5.14 Product safety and quality			x					x				
5.15 Local economy	x	x	x				x	x	x	x	x	
5.16 Decent livelihood											x	
5.17 Labour rights	x					x		x	x			x
5.18 Equity	x		x	x		x		x	x	x	x	x
5.19 Human health and safety	x											
5.20 Cultural diversity	x	x	x	x		x	x	x	x	x	x	x

Since scientists conclude that the concept of resilience is an important tool to measure sustainability (BRAND and JAX, 2007), key functions of a resilient food system are to support food security, while in the same time ensuring resource conservation to enable sustainable development (ERICKSEN, 2008; CABELL and OELOFSE, 2012). The Sustainability Assessment of Food and Agriculture Systems developed by FAO and the Global Environmental Change and Food Systems approach, intending to describe and evaluate all activities, processes and outcomes of modern food systems from farm to fork, outlines that resilient food systems should not only consider ecosystem services they depend on, but should be economically resilient, should enable human wellbeing by good corporate governance - and to stay resilient - need a strong adaptive capacity of stakeholders and institutions as well as policy support to cope with changes (INGRAM et al, 2010; FAO 2012b). King (2008) blamed conventional industrialized food systems to be responsible for ongoing loss in ecosystem resilience and have been kept alive due to trade negotiations, policies and subsidies (KING, 2008; MARSDEN, 2012). Further, King (2008) found out that alternative food systems such as permaculture, organic agricultural systems, farmers markets or community gardens show characteristics of ecological resilience and enhance adaptive capacity through relationship building and collective learning as well as understanding the environment (KING, 2008, 122). Likewise, FAO (SCIALABBA and MUELLER-LINDENLAUF, 2010) and Darnhofer et al. (2010) reviewed organic systems to build resilient agricultural communities especially when faced with climate variability. As FAO (2012b) claimed that principles from integrated agriculture and for organic farming - elaborated by the International Federation of Organic Agriculture Movement (IFOAM) – both intend to enhance resilience through building buffer capacity and diversity, Darnhofer et al. (2009) suggested to take IFOAM principles to build resilience indicators to describe farming systems, the so-called farm resilience (see Tab.11 in the Annex).

At a glance, majority of studies reviewed conclude that locally nested food systems tend to be more resilient due to tighter feedback loops connecting ecological phenomena, producers and consumers, enabling constructive adaptive measurements in case of adverse events, and advocate food systems with short food supply chains (RENTING et al, 2003; GLIESSMAN, 2007; KING, 2008; MARSDEN, 2012). Reasons to shorten food value chains include I) to enable direct contact between farmers and end-users to make work effort and production costs more transparent, to directly exchange consumer and producer desires based on their own experiences and expertise, and to foster moral concepts in relation to food, the so-called resocialisation of food (RENTING et al, 2003; GLIESSMAN, 2007). II) Short food supply chains intend to reshift consumers´ money spent on food from the processing, shipping and marketing side back to primary production by reincorporating processing and transport into farmer´s business (GLIESSMAN, 2007). As in mid-20th-century, European and North-American farmers obtained about “45-60% of the money consumers spent on food”, at the turn of the millennium it was already shrunken to “just 7% in the UK and 3.5% in the USA although the food sector continuous to expand” (PRETTY J, 2001, 2).

According to the concept of resilience, Darnhofer (2005) determines resilience of food systems by buffer capacity, self-organisation and ability to learn and adapt to changing conditions. In case of farm resilience and mostly applicable to the whole food system, Darnhofer (2005) describes buffer capacity as being crucial to absorb internal and external disturbances and is strengthened by flexibility and diversity. Self-organisation is characterised by independency and the chance to self-select appropriate management practises based on needs and desires. Self-organisation needs ability to learn and to adapt. Actors within the food system should be able to adapt to social, political or economic changes and be sensitive for information and signals, should realise and interpret and then adapt processes to changing situation (DARNHOFER, 2005). For more details, see Darnhofer and Milestad, 2003 or table 11 in the Annex.

After Gliessman (2007) socially and ecologically resilient, sustainable food systems are based on bioregional production and consumption to strengthen local communities and sustainable land-use. Further, resilient food systems support diets of plant origin, nutritious, affordable food and disfavour food products that require excessive processing, packaging and transport, which affect eco-efficiency and local farmers' income. Thus resilient, sustainable food systems do not only protect the on-farm environment but contribute to food security, environmental security and other social interests along the entire food system activities (GLIESSMAN, 2007). In times of food price volatilities, Evans (2011) indicates that reduced unemployment rates as well as disaster risk reduction, market transparency and good natural resource governance which avert resource conflicts enhance resilience. To strengthen food system resilience Evans further suggested to avoid competition between food production and biofuel production, to reduce food waste production and promote resource-efficient diets. Koohafkan et al. (2012) further highlight the use of agro-ecological principles such as considering nutrient cycles and ecological footprint of production, distribution and consumption as well as agricultural heritage to stop migration into cities.

To sum it up - at least in a normative theoretical approach - resilient food systems are flexible, innovative, communicative, independent, social, resource-conserving systems.

2.6 The concept of food security in literature

As it is one of the most import outcomes of food systems, following short description of food security and reasons for food-insecurity in the world shall additionally highlight importance of food system assessment.

According to the Food and Agriculture Organization of the United States latest news release about world hunger, about 925 billion people in the world are still undernourished in 2010 (FAO,2010).

In general, food security takes place, “when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life” (FAO, 2003, 29). On the other side, food insecurity exists when “people do not have adequate physical, social or economic access to food” (FAO, 2003, 29).

State of food security is determined by food availability, stability, utilization and access. While *food availability* refers to the ability of the primary sector to meet food demand with animal and crop production, *stability* relates to people at risk to lose access to food because of financial problems, droughts, flood and disease. *Food utilization* covers food safety and food quality, especially sanitary performance along the whole food system. Last but not least, *food access* describes the actual power of consumers, development of food prices and real incomes, addressing adequate and sufficient payment or trade liberalization (FAO, 2003).

Key determinants of steady rising food insecurity seem to be high energy prizes, food crises, financial crises, rising food demand due to economic growth, trade distorting subsidies, insufficient investment in agriculture, environmental damage, bad weather conditions and grant-aided production of bio-fuels competing with food production (FAO 2003, FAO 2009).

In the view of rising food prices and climate change, price changes expected from consequences of global increases of temperature are, altogether, much smaller as compared with changes from socio-economic conditions (FISHER et al., 2002). In essence, the impacts of climate change are globally speaking expected to be very small but at regional level, where agriculture is an important source of income, economic performance from food production is considered to contribute substantially to food security. In this regard, impacts of climate change on economic performance of food production are expected to be severest in Sub-

Saharan Africa, a region with the highest proportion of undernourished people (FAO, 2006).

3 Methodology and data basis

3.1 Ascertainment of climate data

With the intention of generating climate data on the basis of own calculations, raw data from Central Institute for Meteorology and Geodynamics (ZAMG) for the research area Marchfeld was requested and examined, while at the same time close literature research of climate situation in Marchfeld has been realized. Difficulties in calculation – partially due to incomplete time series - but also availability of study results on the basis of already analyzed datasets on climate change in the research area have been decisive factors to fall back on available performances. Moreover, verification of local climate change has never been a task in this thesis. In the following, climate situation in Marchfeld, future climate prediction and agro-climatological as well as hydro-climatological characteristics are summarized.

3.1.1 Local climate situation

Numerous studies examining Marchfeld are based on agro-climatological characteristics pooled by Müller (1993). According to Müller (1993) climate in Marchfeld is characterized by semi-arid conditions caused by climatic transition between maritime western European and continental eastern European climate. Winter times are used to be cold, with little snow but severe frost and summertime is hot and partially dry (MÜLLER, 1993; RISCHBECK, 2007, 19-21; FREYER et al, 2010, 14). At the measuring station Groß-Enzersdorf average annual temperature (1971-2000) was 9.8℃, with highest average temperature of 20.0℃ i n July and lowest in January (-0.4℃) (ZAMG, 2012). Frequency of depress ions is on average higher in winter and spring with rising wind speed especially in case of westerly weather pattern. Summer and autumn are characterized by stable high pressure weather conditions with low wind speed (MÜLLER, 1993). Concerning distribution of rainfall, mean average precipitation rate is highest in late spring (June: 67.4 l/m²) and early summer and fell continuously till October (fig.3). Average annual precipitation level solely comes to 520 l/m² (ZAMG 2012). Freyer et al. (2010), assessing weather conditions in Marchfeld between 2003 and 2009 concluded that within the time period, annual precipitation varied from 428 l/m² in 2003 to 691 l/m² in 2007 with high interannual variability. Hence, Marchfeld belongs to the driest areas of agricultural production in Austria (FREYER et al, 2010).

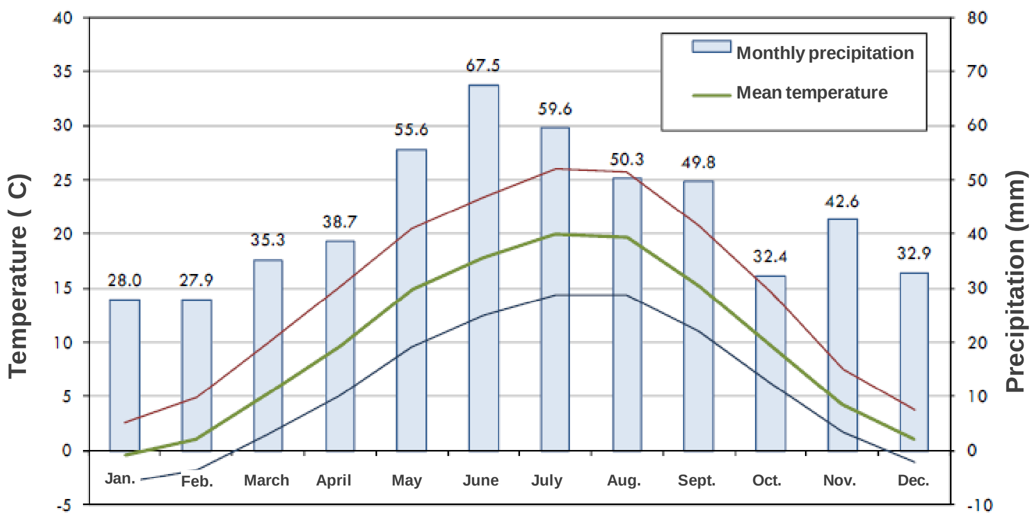


Figure 3. Mean monthly temperature and precipitation amount at the measuring station Groß-Enzersdorf during the period 1971 to 2000

Source: cited in FREYER et al., 2010

3.1.2 Agricultural meteorology

Agricultural sciences, environmental management and meteorology are often interlinked with each other and are focused on single farms, whole production areas respectively national situations. In Austria, Marchfeld counts for the most recorded production areas, providing the basis for a wide range of scientific literature on social, economic and environmental science (RÖTZER, 2004; RISCHBECK, 2007; FREYER et al., 2010). Solar radiation, precipitation and wind strength are just a few direct drivers of crop growth and yield. In Marchfeld, low precipitation amount is a natural limiting factor in agricultural production (RISCHBECK, 2007). Rötzer (2004) summarizes that Marchfeld´s average precipitation amount during growing season of spring cereals from April till July is suggested to be 236 l/m² which impairs superior yields (RÖTZER, 2004). Between 1953 and 1987, according to Rischbeck (2007) about 25% of precipitation-free periods last five whole days. The longer dry periods are, the higher the risk of drought damages in plantation (RISCHBECK, 2007). Additionally, high summer temperature and wind speed lead to high risk of evaporation und in the following enhance drying of the soil. Wind erosion is another challenge due to loss of water storage, especially when vegetation cover is missing (FREYER et al, 2010).

Calculation of the climatic water balance by comparing precipitation amount with evaporation underlines dry areas and expectable water stress for crops within this region and is often used to estimate amount of irrigation. The more negative the value the greater the water evaporation compared to precipitation amount (BMLFUW, 2011c). Hence, Marchfeld definitely counts to irrigation-worthy areas in Austria, which is illustrated in figure 4.

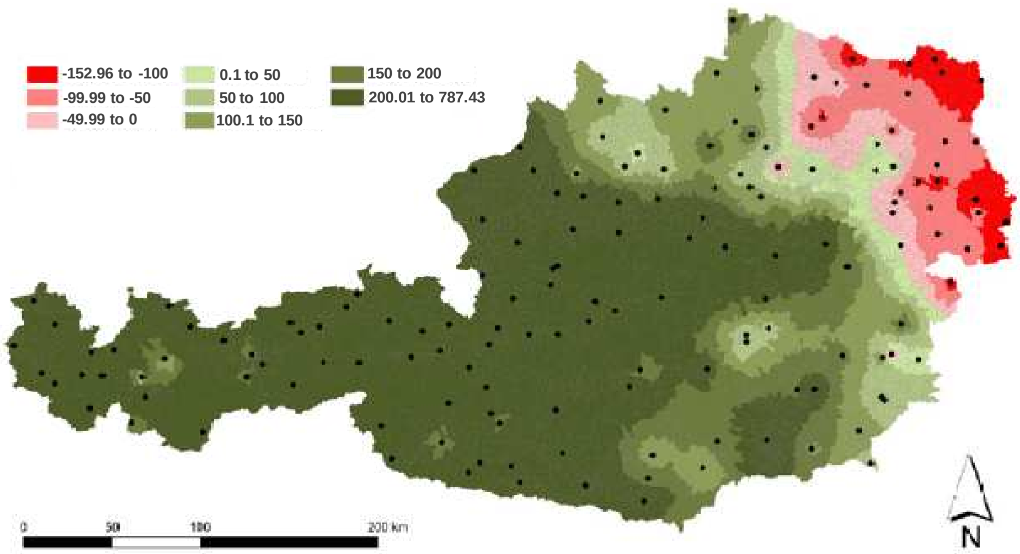


Figure 4. *Climatic water balance in Austria (long-term average during April to September for the period 1961-1990)*

Source: cited in BMLFUW, 2011c

3.1.3 Climate change

After the Earth Summit in Rio de Janeiro in 1992, 195 countries take part in the United Nations Framework Convention on Climate Change to think about global average temperature increases and climate change, indirectly adopting findings from leading climatologists written down in the reports of the Intergovernmental Panel on Climate Change in 1990. Debates resulted in the implementation of the Kyoto Protocol in 1997 (UNFCCC, 2012). Whereas in 2001 in the 3rd assessment reports IPCC working groups conclude that global warming and thus climate change happened “very likely” over the 20th century (ALBRITTON et al, 2001), in the 4th assessment reports in 2007, IPCC scientists agree that Earth´s climate is warming “unequivocally”, indicated by rising global average air temperatures, ocean temperatures, snow melting and sea level rising, putting more emphasis on changing concentration of greenhouse gases and its linkages to anthropogenic activities for reason (ALLEY et al, 2007). Two years later, in 2009, scientists reviewed in an interim evaluation report called the “Copenhagen Diagnosis” that global average sea level is rising more rapidly and sea ice is declining faster than estimated by IPCC in 2007, urging the international community to reduce anthropogenic greenhouse gases emissions radically (ALLISON et al, 2009). In this respect, climate change, adaptation as well as mitigation was and still is a topic of main public concern (see ANDERL et al, 2012).

3.1.4 Climate predictions, models and scenarios

The climate system consists of persistent interacting spheres such as the atmosphere, the biosphere and the hydrosphere and is therefore highly complex and dynamic. These internal dynamics together with external factors such as human induced changes in atmospheric greenhouse gas concentrations or volcanic activities shape climate and complicate assessment of climate and climate change in particular. Fortunately, current achievements in computer technology such as better horizontal and vertical resolution for climate modelling, enlarging data sets in quality and quantity, better understanding in uncertainties together with increasing insight in physical processes enhance credibility of climate change science and thus future climate change projections (SOLOMON et al, 2007).

According to the latest Intergovernmental Panel on Climate Change Assessment Report published in 2007 (AR4) and the follow-up interim evaluation of climate change science in the Copenhagen Diagnosis (2009), climate system is characterised by ongoing warming. At global scale, observed mean surface temperatures have been risen by 0.74℃ ± 0.18℃ between 1906 and 2005, while more recently a tmospheric warming trend becomes even 0.185 ± 0.0052℃ per decade endi ng in 2008. Actually, calculations made by coupled Atmosphere-Ocean General Circulation Models (AOGCMs) simulate increases in global average temperatures of 2 – 7℃ above pre-industrial times by 2100, mainly due to rising anthropogenic greenhouse gas concentrations (Allison et al, 2009). Further observations show rising global mean sea level, which is predicted to climb at least twice as high as estimated in AR4 by 2100, and a noticeable decline in northern hemisphere snow cover, significant increases in reported heavy precipitation events and more frequent occurrence of droughts particularly in tropical and subtropical areas since the 1970s (SOLOMON et al, 2007, Allison et al. 2009).

Looking at regional climate systems, in 2007 European average land and ocean temperatures were 1℃ higher than the average global levels from between 1850 and 1899. Especially in northern Europe warming is likely to be significant in winter time, where especially lowest temperatures are expected to increase above mean values, while in the Mediterranean area increases in temperatures are more likely to occur in summer. In addition, in southern and central Europe increases in highest temperatures will exceed projected average temperatures in summer. With similar certainty, summer droughts are most probably more common in the Mediterranean area and in Central Europe, whereas in northern Europe total precipitation per year is very likely to increase as will precipitation extremes. However, in Mediterranean region annual precipitation is likely to decrease. Lying in between, Central Europe is likely to suffer from lower precipitation rates in summer and higher rates in winter. During the last four decades, snow cover has contracted by about 1.3 % per decade, losses occurred especially in spring and summer (SOLOMON et al, 2007, EEA 2008).

In addition, Austria´s expected mean surface temperature will increase to 3 - 3.5 ±1℃ by 2100 according to the A1B emission scenario and glaciers will probably decline to a tenth of actual size of 1980 (BÖHM et al, 2008).

3.1.5 The consequences of climate change on plant growth

Kromp-Kolb et al. (2008) were using an integrative simulation model, the dynamic plant growth model CERES/DSSAT to simulate plant growth, yield and phenology for winter wheat “Capo”, maize “Ribera” and spring barley “Magda” in Marchfeld for the years 2025 and 2050. Aim of the study was to evaluate vulnerability of local food production to climate change. To compute appropriate results, CERES/DSSAT was fed with data concerning soil quality, crop management information about irrigation, seedtime, fertilization, genetic parameters of the cultivars and meteorological data on a daily basis (THALER et al, 2008). Calibration and Validation of CERES/DSSAT was conducted by available phenological, crop management and weather dataset derived from the meteorological office Fuchsenbigl in Marchfeld for the period 1988 till 2006. Local climate scenarios were based on the global circulation model (GCM) HadCM3 in combination with emission scenario SRES-A2, which corresponds to slow economic growth and growing population as well as CO2 concentration in the atmosphere of 438ppm in the year 2025 and 532ppm in 2050 (KROMP-KOLB et al, 2008). In accordance with results derived from studies made by Kromp-Kolb et al (2008), Eitzinger et al. (2009) outlines impacts of climate change on annual plants for Central Europe and thus Marchfeld as follows:

- Increase in temperature to 2℃ till 2050 will enhance evaporation and thus will lead to water loss for crops. Increase will also result in extreme heat waves and drought during summer time. Together with rising ground-level ozone will harm most cultivars.
- Changes in precipitation rates will influence crop water supply, which leads to growing drought stress for summer crops especially during summer time when precipitation will significantly be lower than at present. Low precipitation rate will also affect nitrogen fertilization.
- Increase of vegetative period to additional 8 days for every decade result in a shift in plant phenology and thus field working days
- Growing extreme weather events such as heatwaves, droughts, heavy precipitation, hail-, storm and frost damage will lead to total increase in annual yield fluctuations no matter if average yield will increase or decline
- Yield potential of local food production will increasingly vary due to soil type and water capacity of soils, benefitting deep grounded soils such as Chernozems and Fluvisols
- Spring crops sensitive to drought stress and spring crops already exposed to sufficient warmth such as spring cereals, potatoes and sugar beet will suffer from water scarcity, heat stress and drought damage, will not increase but rather decline crop yield especially on soils with little water storage capacity and no irrigation practice. Irrigated thermophilic crops such as maize, soybean and sunflower will benefit from additional heat.
- Winter crops will on average benefit as well, due to higher soil moisture in winter. In case of water logging or warmer winter seasons and pest infestation, yield potential will decline too.
- Exotic, thermophilic, heat and drought tolerant, strongly rooted crops will spread
- Irrigated crops will need more water due to rising evaporation.

- Pest control will be challenged due to exotic, thermophilic pests, more rapid spread

Kromp-Kolb et al. (2008) together with Eitzinger et al. (2009) outline the following potential adaptation measures for land-use management to climate change:

- *Farmers shall try to replace plow by minimum tillage techniques and direct seed to avoid soil erosion and support water storage capacity, yield potential, drought stress and transpiration*
- *More efficient methods of irrigation will result in water saving potentials*
- *Selection of suitable varieties will lead to optimal yield potential*
- *Cultivation of more different crops can reduce risk of production and yield loss*
- *Sustainable water supply for irrigation can save food production area*
- *Mulch layers, mulching films, wind break hedges, plastic tunnels, minimum tillage techniques - improving soil quality, supporting hummus layer - can reduce evaporation and save soil water*
- *Crop rotation needs to be adapted to climate zones, cultivating more winter crops in arid regions*
- *Cultivation of stress-tolerant spring crops*
- *Development of better suited fertilizer and planting equipment*
- *Thermophilic, late-maturing cultivars can increase yield potential*
- *advancement in times of cultivation and harvest*
- *implementation of assurance opportunities and funds in case of yield losses due to climatic conditions*

3.2 Ascertainment of social, economic and ecological situation in Marchfeld

Generally speaking, implementation of systems analysis is often time consuming and resource intensive. Looking closely at the evaluation report of the Millennium Ecosystem Assessment, despite outstanding findings concerning ecosystem conditions, majority of sub-global assessments were underfinanced and suffered from limited capacities of important institutions. Additionally, the MA project lasted five whole years but was originally planned to be finished in three years (WELLS et al., 2006). With this background knowledge, methodological principals for data generation have been collected and adapted for food system assessments.

Data generation is based on the following methodological principles (see also FAO, 2012b, 17f):

- Cost and time efficiency:

  In order to leave a maximum of resources for interviewing experts, planning and organizing workshops, group discussions, surveys and follow up research and to avoid duplication of work, basic data generation is narrowed by making the best use of existing, easy available data with focus on frequently updated quantitative analysis and long time series of comparable data. Use of data is rated at quantitative absolute to quantitative relative to qualitative absolute to qualitative relative information.

- Adaptability and Transparency:

  Procedure of data collection is easy to repeat and offer a wide range of variations to allow scientists from various fields to apply sustainability assessment to the EASEY model but for different tasks.

- Relevance:

Data collection shall give the best possible overview of the whole food system, shall take into account diverse aspects of food security, shall be valuable to people with a stake in food production performance, especially within the local food system such as farmers or small retailers.

- Future orientation and open learning:

Data generation provides a basis for scientists and stakeholders to continue and develop processes concerning food security, shall serve as a starting point to encourage collaboration between scientists and policy makers and shall help to improve sustainability assessment within the EASEY model.

Usually, single point of contact to sustain reliable economic, social and political data is Statistics Austria, which provides useful data at area of production-level concerning crop area, farming types, standard gross margin, but also classical statistics such as demographic statistics, structure of labor force, education and tourism. However, mostly, annual updates of existing data sets are missing (STATISTICS AUSTRIA, 2012a). More detailed view on agricultural production and performance can be obtained from the Austrian Federal Ministry of Agriculture (BMLFUW), providing annual data on crop area, livestock, farming type, labor requirements, participation in environmental programmes such as ÖPUL and farm payment at community-level, collected in INVEKOS data set (BMLFUW, 2011b). Additional information on food production can be found in the Green Report (BMLFUW, 2010a; BMLFUW, 2011a), which is available annually at national and regional level, and in numerous scientific papers and reports (FREYER et al, 2010). However, difficulties emerged in generating data concerning marketing channels.

The following table gives an overview on existing, collected data along the food value chain according to HAWKES and RUEL (2011, 4).

Table 2. Web pages relevant for the Marchfeld according to the food value chain

Source: own collection; structure based on HAWKES and RUEL (2011, 4)

Website	Description
Inputs into production	
www.saatzucht-donau.at	breeding with emphasis on winter wheat and winter barley, but also: spring barley, sunflower, winter rye, durum wheat, no business report available
www.landesprodukte-rupp.at	Rupp HandelsgesmbH Co KG, seed, pest control, fertilizer disposal
www.statistik.at	Statistics Austria (agricultural price statistics)
www.lbg.at	LBG Austria GmbH (accounting results of farmers, expenditures on agricultural inputs)
Food production	
www.bmlfuw.gv.at	Austrian Federal Ministry of Agriculture: INVEKOS database (crop area, ÖPUL evaluation)
www.statistik.at	standard gross margin, demographic statistics
www.noe.gv.at	Department of veterinary issues and food controlling (number of organic farms)
www.gruenerbericht.at	Austrian Federal Ministry of Agriculture, Green Reports (social and economic situation of agriculture in Austria)
study reports see bibliography:	FREYER et al. 2010; HAMBRUSCH and QUENDLER, 2008
Primary food storage and processing	
www.eom.at	Marchfeldgemüse GmbH (producer organization)
www.lagerhaus-marchfeld.at	Raiffeisen Lagerhaus Marchfeld reg. Gen.m.b.H. (crop purchase, storage and disposal)
www.haas-marchfeldgemuese.at	Haas Handels GesmbH, crop production , storage,

Website	Description
	packaging, delivery
www.raidl-gemuese.at	Lahner Raidl GesmbH, vegetable production, packaging, delivery
secondary food storage and processing	
www.iglo.at	Iglo Austria GmbH (frozen vegetables)
www.gemueseland.at	Landesproduktenhandels GesmbH, fresh vegetables, frozen vegetables, organic vegetables, storage, packaging, delivery
www.agrana.at	Agrana Austria GmbH (sugar production)
www.geier.at	Ideenbäckerei Geier GmbH (bakery, confectionary)
www.schottenobst.at	Fruit production, fruit processing, direct marketing
Food distribution, transport, and trade	
www.eom.at	Marchfeldgemüse GmbH
www.adamah.at	Organic crop production, direct marketing
www.spargel-harbich.at	asparagus production, direct marketing, delivery to hotels
Food retailing and catering	
www.rewe-group.at, www.spar.at	Annual reports of REWE 2011, SPAR 2010
Food promotion and labeling	
www.genuss-region.at	Marchfeld Gemüse, ARGE Marchfeldspargel
www.ama-marketing.at	Agrarmarkt Austria Marketing GmbH, agricultural marketing, quality assurance programmes, seals
www.regionmarchfeld.at	Local Agenda 21, improved use of Marchfeld castles, Marchfeld channel cycle way

3.3 EASEY methodology

3.3.1 Initial situation, objectives and context

Food systems are changing rapidly. Thanks to modern technologies food production is able to meet demand of growing world population. However, imbalanced food distribution still challenges many citizens, countries and even regions. Besides, techniques, innovations, policies and practises, which made increasing productivity possible, have unsettled foundations of this productiveness. According to this disproportion, but also as a response to great concern mentioned at the United Nations Conference on Environment and Development in Rio de Janeiro (1992) about global future social, environmental and economical development and the general political agreement to weight interests of economy, society and environment equally, global and regional management and governance will need to establish integrative models considering ecological, social and economic factors to promote more resilient and sustainable production systems to ensure present and future development. Within the EASEY model, the Ecological And Social EfficiencY model – formerly developed to visualize "an integrative concept for the evaluation of sustainability achievements of enterprises noted at Vienna´s stock exchange" (PAULESICH et al, 2006a, 8) - an innovative approach is undertaken to establish a holistic assessment to evaluate performance in social-ecological systems.

Between 2001 and 2003, under the auspices of the Federal Ministry for Transport, Innovation and Technology, an approach was undertaken to create an integrative concept in order to evaluate sustainability performance of notable enterprises, whose shares could be dealt at Vienna`s stock exchange. A manual was produced providing a data set of sustainability indicators. Further, applicability to evaluate performance of enterprises was assessed and the EASEY Index created, which should lead to a daily update of sustainability performance (PAULESICH et al, 2006a).

On the basic assumption that indicators need to be interlinked with each other to provide meaningful information and underline scientific evidence, the EASEY indicators should identify impact of corporate activities on stakeholders and further evaluate performance in respect to superior development goals for long-term effects which need to be developed and then evaluated with broad public participation by means of online surveys and in parallel expert voting (PAULESICH et al, 2006a, 6f).

Procedure to develop a manual of sustainability indicators to evaluate performance of enterprises was conducted as follows: desk research on corporate sustainability concepts, secondary analysis of data and concepts in form of annual reports of companies and environmental reports, brainstorming, group interviews, workshops and two surveys (PAULESICH et al, 2006a).

In order to provide meaningful results, the EASEY model has been developed to interpret consequences of performance within a comprehensible framework (PAULESICH et al, 2006b).

According to macroeconomic model theory (see MANKIV, 1996, 9f), models are used to

1. Depict reality in order to formulate statements that are valid in general.
2. Create a new understanding of fundamental interrelationships between single elements such as indicators or variables.
3. Create a new understanding of vulnerability and resilience to external stressors
4. Allow individual evaluation to benefit enterprise and stakeholders.

To evaluate enterprises respectively social-ecological systems, already existing information must be available and missing data discovered and then collected to complement data set along the whole value chain, which enables association of individual process stages along the whole life cycle of products.

3.3.2 Dimensions of the EASEY model

The EASEY model consists of the following three dimensions: 1) value chain dimension, helps to analyse output, processes, causes and consequences of production on stakeholders, 2) stakeholder dimension, shall capture the whole range of stakeholders, their needs and shall serve to identify activity of enterprises to enhance use for stakeholders, 3) goal dimension, figures enterprise performance in respect to sustainable development, to enable long-term existence of human life with focus on stakeholders (PAULESICH et al, 2006a, 35).

New version of the EASEY model is scheduled to support more sustainable performance in local food production with regard to environmental, economical and social progress.

Following figure shall ease traceability of the EASEY model approach to evaluate sustainability performance of enterprises respectively food systems:

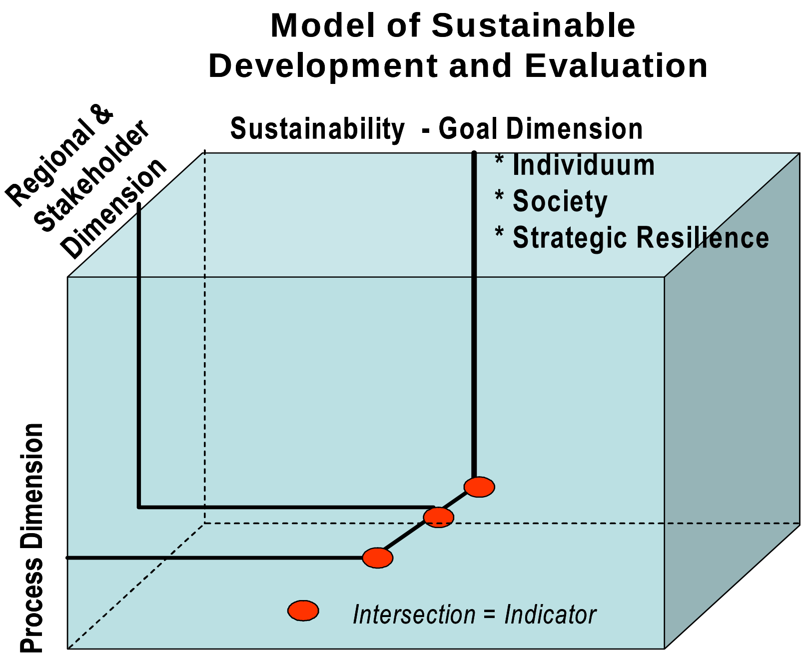


Figure 5. The EASEY model of sustainability indicators
Source: PAULESICH et al, 2007b

Process dimension

The process dimension focus on supply chain from the very beginning of agricultural production right up to waste disposal. This presupposes that the concept respectively this model respectively methodology can solely be adapted when there exists a process chain consisting of suppliers, farming, processing, transport, market and waste disposal (PAULESICH et al, 2007a). According to Stephen R. Gliessman, founding director of the University of California, Santa Cruz, Agroecology Program and cofounder of the nonprofit Community Agroecology Network, modern food production is handled like an industrial process with plants and animals filling the role of tiny factories, in which output is maximized by supplying the corresponding inputs, productive efficiency is increased by gene manipulation and their locations are as rigidly controlled as possible (GLIESSMAN, 2007,3). From this point of view, it is not far-fetched to envision that food systems can be seen as, in this case, big factories as well, especially in view of the fact that most of the actions taken within the food system are carried out by transnational companies, often holding firms at every link in the food system chain, called vertical integration into the food system. The number of these enterprises has been declined giving rise to several agrobusiness corporations to control the agriculture sector of many countries (GLIESSMAN, 2007).

To gain an overview of Austrian´s food economy, national food economy report, the most recent Green Report and agricultural statistics developed by Statistics Austria have been analyzed and crucial indicators based on quantitative data collected to evaluate performance (BMLFUW, 2010b, BMLFUW,2011a, STATISTICS AUSTRIA, 2012a).

It is remarkable that food economics play a vital role in national economy, contribute with approximately 12% to the annual gross domestic product and provides working places for about one in six Austrians (BMLUFW,2010b). However, in 2010 the share of agriculture together with forestry and fisheries in annual gross domestic product was solely about 1.5% (BMLUFW, 2011r). In addition, Statistics Austria estimates according to results of the structural survey of agriculture in Austria 2010, about 173,317 agricultural und forestry holdings, but number is declining by on average 4,200 agricultural holdings per year during the last 15 years (STATISTICS AUSTRIA, 2012a, 22). Further, income per non-waged person was € 17, 508 per year, including subsidies for almost 126,800 agricultural and forestry holdings (BMLFUW, 2011a), whereby income level varies significantly between agricultural farming systems and production area (LBG, 2011).

Besides, main characteristic of agricultural production by contrast with other industrial or commercial production is its direct linkage with nature, local climate system and weather in particular. In general, food production belongs to economy and society but it is mainly part of the superior system nature. Thus, food production messages vary tremendously from subsystem economy, which is more strongly embedded in “society” than in nature. To put in a nutshell, food production stakeholders are not able to apply their specific logics for other subsystems. For that reason, decision-making and management are not any longer under control of farmers themselves but business of modern, technology-driven agro-industry. Smallholders appear to have not enough power to cope with industrial agriculture and to compete successfully with large-scale farms (PAULESICH, 2007a). Further trends and characteristics of farming which should be integrated into indicator development can be found in chapter 2.5 of this thesis, summarizing common trends in agricultural production.

Situation of primary food processors such as millers and refiners is characterized by small to medium enterprises with on average 11.5 employees per enterprise. Solely about 0.4% of enterprises belong to big enterprises with more than 250 employees. Highest amount of production value derives from sorcerers and the food and beverages sector, lowest from patisserie and millers. On the whole, primary food processors have 1.3% of total production value of the services´ sector. Secondary food processing is Austria´s strongest industrial sector with a production value of 7.2 billion EUR in 2009, whereby 4.1 billion EUR derived from exported products traded mainly to the European Union, other European countries and North America. Since 2007 numbers of enterprises and employees are stable or rising slowly. Secondary food processing is characterized by saturated national market, highly competitive export markets and high pressure derived from food retailers and indirectly consumer demands. To be competitive, Austrian´s food industry needs to be innovative within the global market. Thus, it is characterized by trends in functional and convenience products, innovative production of traditional, organic and local goods but lacks in cooperation between primary processors and food industry as well as within the industrial food processors themselves. Austria´s food retail trade is famous for its high market concentration, whereas 79.2% of total turnover of retail trade were covered by the food retailers Rewe, Spar and Hofer. Discount traders gain importance as well as home-made brands, online shopping is going to be important and convenience markets gain ground at different trade locations such as airports and railway stations. Direct distribution channels for primary producers are in the first place sale directly from the farm, followed by farmers´ markets and home delivery, while eggs, potatoes, vegetables, fruits and fresh meat have the greatest value. The initiative Austria-Region of Delight (Genuss Region Österreich) is promoted by Agrarmarkt Austria Marketing GmbH and the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) highlights typical local products in 113 Austrian Regions of Delight. Tourists alone spent on average 25 EUR on food and beverages per day in Austria. Catering industry is getting important especially due to fast food and restaurant chains, self-service restaurants and hypermarkets (BMLFUW, 2010b).

Concerning food consumption, there has been a slight decrease in per-head consumption of beer, wine and meat in general, while poultry meat and fish is characterized by market growth. Consumption of milk products is rising too such as of vegetables and fruits. Austrians tend to eat regularly whereby meals at noon are preferred most. Whole food and vegetarian food is getting popular as well as meals containing local, seasonal products. Easy recipes which afford little time to cook after are welcome as well (BMLUFW, 2010b).

In this dimension data is collected first at national level (BMLFUW, 2010b), which is summarized in the sections above, to find out crucial indicators for food economics. Then, findings at local level are collected and can be compared with data from competitors to realise efficiency and effectiveness of food production particularly with regard to goods and services. Ecological efficiency of food production is measured by comparing applied material, energy, labour and extant amount in products. Otherwise, effectiveness depends on need of repairs respectively applicability of products. In case of food production, effectiveness could be simply nutritional value or in other words contribution to health by food intake. Because nutritional value is difficult to measure and to compare, contribution to food security is measured on the basis of guidelines for the whole food diet designed by Leitzmann (2010) (see Table 8), for healthy adults. Effectiveness also provides information about strategic investments in current achieved yields when farmers are driven by market opportunities mediated by large entities of food processing such as frozen food producers Ardo Austria Frost GmbH in Groß Enzersdorf (PAULESICH, 2007a).

Data of prime importance will result from use of external inputs such as irrigation water, pesticides, antibiotics and fertilizers which can be classified as material substances. Energy to produce these substances, to launch machineries at the farm and irrigation facilities, air-condition in storage rooms, animal factories or conservatories in wintertime but also technology which is needed to create hybrid or transgenic seeds, new agrochemicals and new powerful farm machinery are substances which derive from outside the farm. Widespread use of these inputs makes farms highly dependent on these non-renewable resources, shift profit of farmers and affect place of control of agricultural production. To bear in mind, intensified agriculture was able to increase its yields mainly by raising external inputs (GLIESSMAN, 2007). However, intensified agriculture and the use of intensive tillage which should beneath others loosen soil structure for a better drainage and aeration, and should make sowing of seed easier, to reduce germination of weeds and to dig in remaining crop residues, tends to leave the soil free and uncovered for longer periods, increasing wind and water exposure, and heavy farm machinery is more often used on the fields. In addition, cultivating only one crop in case of monoculture, makes the use of machineries more efficient because machinery could be adjusted to meet the requirements of only one single crop and labour inputs are minimized and technology inputs maximized to ensure productive efficiency but lead to soil degradation which is already discussed above. Monoculture is closely linked to intensive cultivation, use of inorganic fertilizer, irrigation, specialized plant varieties and control of pests through agrochemicals which is necessary to protect homogenous plants to specific pests which find optimal conditions to spread rapidly at this field. These practises, which lead to soil degradation, are widespread and cause more and more use of fossil-fuel derived nitrogen fertilizer. All in all, dependence on external resources boosts vulnerability to price increases, supply shortfall and market fluctuations (GLIESSMAN, 2007).

In this context, data about fertilizers especially synthetic fertilizers from which mineral components leach out easily of the soil and might end up in groundwater, posing a health hazard; pesticides, agricultural technology including the whole infrastructure of production processes like transport and waste disposal; livestock breeding, plant breeding, animal feeding stuff, animal health, stable technology and regulation of agribusiness is necessary to interpret resilience of areas which are located in front of the agricultural sector.

Table 3. Possible available, accessible information along the food value chain

Source: LBG, 2010; BMLFUW, 2011; Statistics Austria, 2012a

Inputs into food production	**Food production**	**Primary and secondary food storage and processing**	**Food distribution, transport, and trade**	**Food retailing and catering**	**Food promotion, labeling, Waste disposal**
Expenditure on seeds, pest control and fertilizer, machines and gadgets, irrigation, energy input	Area according to main crop cultivars, producer prices, organic and conventional production, Standard Gross Margin	Annual reports of main enterprises within the production area, food quality according to guidelines of whole food diet	Sale directly from farms, cooperatives, retailers, distance between producers, processors and consumers	Restaurant and supermarket chains, fast food companies	Advertising, main brands, *Genuss Region Österreich*, facts and data concerning tourism within this area

Stakeholder dimension

The EASEY model also considers the role of stakeholders even those assigned to the non market environment influencing decision-making and procedure model in companies. There exist several basic types of individuals and groups who have a stake in the farming and food system (PAULESICH, 2007a).

Farmers, count due to their position in the food value chain, provision of public goods such as food security and agricultural landscape, and number of individuals, to the most important stakeholders within the value chain. In Austria more than 93% of farms run as family businesses, about 40% of it in form of a main occupation. As a result, majority of farm workers are unpaid family members. Other stakeholders within this group are seasonal workers, paid agricultural workers, commodity producers and so to speak all individuals who directly work in the fields and their representations of interests (BMLFUW, 2011a).

Further important stakeholders belong to the group “market” consisting of upstream economic sectors such as input suppliers delivering physical inputs of seeds, machineries, pesticides, fertilizers and feedstuffs, as well as service providers, cooperation partners, market regulatory authorities and downstream economic sectors such as retailers and supermarket chains, the latter continuously gains market power due to high concentration of enterprises providing more and more private labels which indirectly push down producer prices (BMLFUW, 2010b, 53).

The stakeholder group “society” comprises following stakeholders: national and public institutions, but also media and publicity which evaluate influence of company´s activities on social and cultural values. This group also consists of regional, local communities and their rural residents who live next to the farmland and may work in the food system (PAULESICH, 2007a). In general, Austrian population confirms trends towards shorter holidays and daytrips, tourists and countryside visitors like to value the countryside for its landscape as it is a reliable guarantor of experiences, wildlife, cultural events and several leisure-time activities. Thereby, quick accessibility plays a vital role and makes urban surroundings more attractive (WKO, 2008).

Environmental organizations such as nongovernmental organisations , local action groups, universities of life sciences, environmental authorities and critical publicity also belong to the major stakeholder group “environment”, as they act on the behalf of the intrinsic stakeholder environment which consists of animals, plants, soil, water, air, raw materials, ecosystems and landscapes which are not able to express themselves (PAULESICH, 2007a).

Another important stakeholders are food consumers, both urban and rural, private, public and commercial end customers, who increasingly buy food from large retailers and thanks to modern logistics purchase food from distant regions. In general, consumers characterize organisms which ingest at least parts of other organisms to acquire nutrients and energy. In case of economics, consumers are ones who acquire goods and services or are simply described as buyers. However, buying and eating food is more than just constructing and reconstructing the body. Consumers are responsible for their choice, they need information to make a good choice and must be engaged to ensure a sustainable food system (WILKINS, 2005). The concept of “food citizenship” described by Jennifer Wilkins meets the requirements for a sustainable food system. Food citizenship is defined as “practice of engaging in food-related behaviours that support, rather than threaten the development of a democratic, socially and economically just, and environmentally sustainable food system” (WILKINS, 2005, 271).

Agribusiness has successfully manipulated consumer tastes and purchasing behaviour, promoting beef, pork, fast food, high processed snacks, exotic fruits and out-of season vegetables and in other words, products with the highest profit potential and unfortunately with the highest environmental costs too. Consumers are isolated from the production and distribution process, but also from relevant information and knowledge which is important to become conscious of the negative impacts of their behaviours, diets and food choices. Disconnecting farmers and consumers altered the way of communication among the actors in the food system. Information which circulates in the system is often controlled and conveyed by another stakeholder group termed as manufacturing, processing, trading, and retailing companies, which operate as stakeholders as well by taking farm produce from the farm area, move it, transform it and sell it. They receive more than 90% of the food dollar spent from consumers. These stakeholders are less interested in educating consumers in economic circumstances, origins and processing of the food they produce but promote attributed effects on identity and image, and point out how food can be more convenient and less work (GLIESSMAN, 2007, 327ff).

Finally, “donors” such as credit granters, banks, families who produce goods of higher value at their farms and indirect the European Union and governments, both local and national have a stake, arranging agricultural furtherances and set policies that restrain all stakeholders and act on behalf of the public (PRETTY, 1998). In Austria, in 2010, about 47% of total income per farm arises from public sponsorship (LBG, 2011, 20). According to this public engagement, ensuring food supply within national borders seems to be of special societal interest. However, same policies have kept market prices more or less stable and have left many farmers under pressure of increasing input production costs and marketing costs (LBG, 2011, 11).

There exists a wide range of data to evaluate effectiveness and efficiency of stakeholder dimensions. For instance, social responsibility and quality of products can be measured by comparing tendency to reduce the value of diet with life-supporting expenditures in general or time exposure in relation to spare time or career. Consumers´ surveys about preferences and satisfaction are often carried out to measure information exchange and food choice and further the ability of local farmers to supply the market (PAULESICH, 2007a).

Table 4. Major stakeholders along the food value chain
Source: own calculations for Marchfeld adapted from PAULESICH, 2007a

Farmers,	**Society**	**Clients**	**Market**	**Donors**	**Environment**
Farmers, unpaid family workers, agricultural workers, seasonal workers, commodity producers, Trade unions, associations and chambers: Provincial Chamber of Agriculture of Lower Austria/Vienna , District chamber of Agriculture of Gänserndorf, farmers association of Lower Austria, sugar beet growers´association, Federal Vegetable production association (Bundesgemüsebauverband Österreich)	National and public Institutions: University of Natural Resources and Life Sciences, Federal Ministry of Agriculture Forestry Environment and Water Management Communities , local action groups: Leader-region Marchfeld, BIM (citizens initiative Marchfeld), NGOs: Eco Counselling Austria, BirdLife Austria, Distelverein, Media: daily newspaper, virtual media, Bezirksblatt Gänserndorf, Forum Marchfeld ,general public	Professional and general retail clients in Vienna Region, traders: Producer organization Marchfeldgemüse GmbH CO KG, Raiffeisen Lagerhaus Marchfeld eGen mbH, processors: Iglo Austria GmbH, Agrana Zucker GmbH, Ideenbäckerei Geier GmbH, consumer protection association: Verein für Konsumentenschutz	Input providers:, Probstdorfer Saatzucht GesmbH & CoKG, service providers: Maschinenring Österreich, subcontractors , cooperation partners: Raiffeisen Regionalbank Gänserndorf reg.Gen.m.b.H , competitors, market regulation agencies: Agrarmarkt Austria, Austrian Agency for Health and Food Safety, supermarket chains, retailers	Promotion of agricultural production: Federal Ministry of Agriculture Forestry Environment and Water Management, European Union; Creditors, banks: Raiffeisen Regionalbank Gänserndorf reg.Gen.m.b.H; shareholders, bondholders	Wild animals, plants, soil, water, air, raw materials, ecological systems, landscape respectively animal safety organizations: Distelverein, BirdLife Austria, Global 2000, other NGOs with ecological stakes, expert-media, environmental agencies, in general people interested in social-ecological issues

Linking findings from both dimensions, the process dimension and the stakeholder dimension, together leads to comprehensive understanding of efficiency and effectiveness in case of common and national agrarian policy, and allows evaluation of marketing opportunities for food and food items, considering produce, prize and amount.

Goal dimension

Long-term efficiency of control measures for food system sustainability can only be validated when corresponding goal dimensions exist. Short- and middle-term target values already are taken into account on a microeconomic as well as regional respectively macroeconomic scale at the process and stakeholder dimensions. Assessment of sustainability and workout of new perspectives to ensure sustainable development need longer-term horizons. For this purpose, already existing sustainability rules on the basis of the Helmholtz Association approach (see KOPFMÜLLER et al, 2001) are used as goals to evaluate regional economic development. This goal system does not substitute individual goals of food system participants. It shows up opportunities and limits with regard to sustainable development. A concept of participant goals within this process is ancillary to a concept of sustainability goals, which represents interests embedded in multilateral agreements, international principles as well as political intentions of the European Union concerning sustainable development. In a system of sustainability goals, the whole food value chain but especially agriculture is part of more than one category in the sustainability goal dimension. However, adaptation steps are needed which requires knowledge from local experts to apply this concept in a particular study area (PAULESICH, 2007a).

Table 5. The three goal dimensions of sustainable development and their subsystems

Source: cited in PAULESICH et al., 2006a, 42

Ensuring human existence	
	Maintaining human health
	Safeguarding basic provision
	Securing an independent livelihood
	Compensation of income and asset disparities
	Fair distribution of natural resources
Maintaining the social productivity potential	
	Sustainable use of renewable resources
	Sustainable use of non-renewable resources
	Sustainable use of the environment as a sink (for waste)
	Avoidance of intolerable technical risks
	Sustainable development of physical, human and knowledge capital
Maintaining the opportunities for development and action	
	Equality of chances
	Participation in social decision-making processes
	Cultural heritage and cultural diversity
	Safeguarding the cultural function of nature
	Maintaining social resources

3.3.3 Supplements in respect to resilience thinking

According to other assessments dealing with resilience in social-ecological systems (see CABELL and OLEOFSE, 2012) it is important to start with defining the boundaries of the system of interest namely the food system in Marchfeld, the so-called resilience of what. Like many studies focusing on Marchfeld, the boundaries of production area Marchfeld are based on its biophysical properties dedicated to production such as the rivers Danube in the south and the river March marking the eastern boundary. According to modern food systems, it is nested in various scales to reach the markets of interest or get the right resources (inputs) in order to grow adequate cultivars. This relationship needs to be identified as well and helps to realize the ways other systems affect production area. Simultaneously, area needs to be measurable, and is therefore dedicated to core communities within the small production area Marchfeld, which are statistically portrayed and information is up-dated.

Beneath resilience of what, the so-called resilience to what requires to be defined. It is the disturbance of interest, affecting the focal system that has to be fixed. In this case, climate change is the subject of research, but crucial drivers call for identification as well to elaborate interactions within the system. A historical profile of the food system of interest can help to discover other system drivers but also can list significant events and changes over time which have formed the current system (RESILIENCE ALLIANCE, 2010). Thus, resilience assessment of Marchfeld is based on following characteristics:

System boundaries:

<u>Biophysical boundaries:</u>

in the north: mountain Großer Wagram

in the east: river March,

in the south: river Danube

in the west: mountain-chain Bisamberg (FREYER et al, 2010)

<u>Communities dedicated to Marchfeld within the biophysical boundaries:</u> Aderklaa, Andlersdorf, Deutsch-Wagram, Eckartsau, Engelhartstetten, Gänserndorf, Gerasdorf bei Wien, Glinzendorf, Groß-Enzersdorf, Großhofen, Hagenbrunn, Haringsee, Lassee, Leopoldsdorf im Marchfelde, Mannsdorf an der Donau, Marchegg, Markgrafneusiedl, Obersiebenbrunn, Orth an der Donau, Parbasdorf, Raasdorf, Strasshof an der Nordbahn, Untersiebenbrunn, Weiden an der March, Weikendorf, Wien-Donaustadt, Wien-Floridsdorf (see STATISTICS AUSTRIA, 2012c)

Historical profile of major events and developments affecting the production-area Marchfeld to find out crucial drivers and disturbances of the focal food system and effects of interventions:

2012 *construction of a windfarm in Glinzendorf/Markgrafneusiedl (WIEN ENERGIE, 2012)*

2011 *Iglo starts own sustainability programme "Forever Food" (IGLO, 2012)*

2011 *Opening of adventure park Gänserndorf (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

2007 *ÖPUL 2007 (BMLFUW,2012a)*

2006 *Unilever sells frozen food production to Permira and is part of the Birds Eye Iglo Group (IGLO, 2012)*

2006 *ground water is rising due to heavy precipitation (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

2004 *EU Eastern-Expansion (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

***2003** harvest losses due to extreme drought (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

***2000** ÖPUL 2000 (BMLFUW,2012a)*

***1998** foundation of Austria Frost Nahrungsmittel GmbH (IGLO, 2012)*

***1998** fusion of Lagerhaus Obersiebenbrunn, Gänserndorf and Deutsch-Wagram to Lagerhaus Marchfeld (LAGERHAUS MARCHFELD, 2012)*

***1996** foundation of Erzeugerorganisation Marchfeldgemüse GmbH & CoKG, association of farmers (ERZEUGERORGANISATION MARCHFELDGEMÜSE, 2012)*

***1996** foundation of national park Donau-Auen (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

***1992** provisional finalization of Marchfeld channel system (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

***1995** Austria enters the European Union (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

***1989** opening of the border, fall of the Iron Curtain (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

***1988** foundation of sugar holding AGRANA Zucker GmbH (AGRANA, 2011)*

***1986** construction of Marchfeld channel to rise groundwater level starts (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

***1970s** shrinking groundwater level due to irrigation practises and low precipitation amount (REGION MARCHFELD, 2011)*

***1965** Unilever moves to Groß Enzersdorf (IGLO, 2012)*

***1965** high floods in Marchfeld (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

1963 *foundation of Iglo Feinfrost GmbH (IGLO, 2012)*

1962 *Unilever assumes frozen vegetable production in Raasdorf (IGLO, 2012)*

1953 *first corporate irrigation plant in Schönfeld in Marchfeld (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

Since 1950s *quotation of sugar production because of surplus production*

(DIE RÜBENBAUERN, 2002)

1946 *„Petter“ enterprise produces frozen vegetables in Raasdorf/Marchfeld (IGLO, 2012)*

1934 *Austria is able to be self-sustaining with sugar production (DIE RÜBENBAUERN, 2002)*

1932-33 *economic crises, emigration to the land, establishing allotment garden (SCHILDER, 1970)*

1905 *foundation of “Niederösterreichischer Rübenbauernbund” (DIE RÜBENBAUERN, 2002)*

1905 *flood control of the river “Morava”, construction of “Hubertusdamm” (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

1902 *foundation of sugar factory in Leopoldsdorf (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

1900 *commencemet of Lagerhaus Obersiebenbrunn, an agricultural cooperative (LAGERHAUS MARCHFELD, 2012)*

1899 *high floods of the river Danube in Marchfeld (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

1889 *reallocation of land started in Obersiebenbrunn (first of Austria) to meet requirements of modern agricultural practises, to enable rationalization (LANGTHALER and SINABELL, 2007)*

***1885** afforestation starts: timber, windbreak, soil moisture, rural conservation, (SCHILDER, 1970)*

***1870 – 1902** flood control of the river "Danube", construction of Marchfeld flood protection (PICHLER, 2011)*

***1848** dissolution of hereditary serfdom (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

***1838** opening of railway line "Nordbahn", first steam-driven railway of Austria: Floridsdorf – Wagram (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

***1830** Danube at high watermark (PICHLER, 2011)*

***Since the end of 19th** century rural flight to Vienna (SCHILDER, 1970)*

***1792** cultivation of millet, later wheat (SCHILDER, 1970)*

***1770** climax of sheep raising at fallow land, formation of flying sand through previous deforestation and crop production (SCHILDER, 1970)*

***1750** flying sand on 3000 acres (SCHILDER, 1970)*

***1501** Danube at highest historical watermark (PICHLER, 2011)*

***1350** subsistence farming, 3-field-crop rotation in combination with sheep raising (SCHILDER, 1970)*

***1402** high floods of the river Danube (LANDESMUSEUM NIEDERÖSTERREICH, 2012)*

***12th** century beginning of land-use intensification, transition from payment in kind into monetary payment, density of local population increases dramatically (SCHILDER, 1970)*

***1000 AD** alluvial forests (cottonwood, alder tree, elm tree, willow) frequently flooded by numerous branches of the Danube, steppe formation at dry locations (SCHILDER, 1970)*

***20.000.000 AD**, formation of Vienna Basin*

Further characteristics of resilience assessment in Marchfeld belong to the focal production line respectively a more concrete food value chain as an example for food system research within the EASEY model. The approach consisted of the following steps: First, preparation of data on crop production in the Marchfeld region, in Lower Austria and total agricultural crop production of Austria. Second, comparison of the structure of crop production and third, assessment of the whole production line of the main crops as well as crops with an extraordinary high share within the Marchfeld region (BMLFUW, 2011b).

4 Results and discussion

4.1 Short description of Marchfeld region

Marchfeld belongs to one of the greatest basins in Austria, the Vienna Basin, paved by the river Danube 20,000,000 years ago and is situated partially within the borders of Vienna city while the greatest part belongs to Lower Austria (STATISTICS AUSTRIA, 2012c).

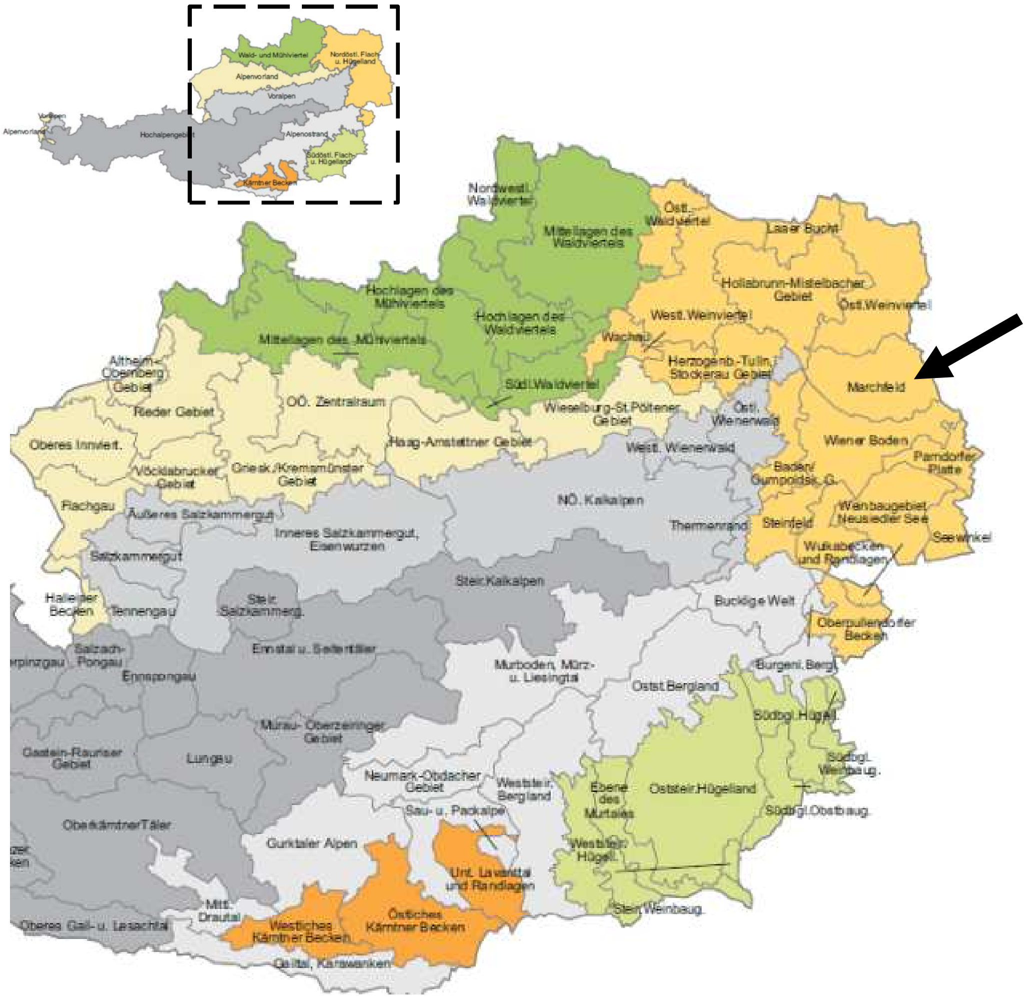


Figure 6. Map of agricultural production areas in Austria, incl. Marchfeld
Source: STATISTICS AUSTRIA, 2012b

It is a small production area of about 1,000km² and part of the main production area “Nordöstliches Flach- und Hügelland” (see light-orange zone in Fig 6). According to Statistics Austria, Marchfeld consists of 25 communities of Lower Austria and 2 districts of Vienna (see STATISTICS AUSTRIA, 2012c). Total area is between 137m and 165m above sea-level (NESTROY,1973). In respect to agricultural production, Marchfeld belongs to the driest production areas of Austria with precipitation reaching only 500 till 600 mm per year and temperatures estimated to rise by at least 2℃ till 2050s. Further estimates belong to ongoing water-loss due to evaporation till 2050s, phenological shifts in crop cultivars, increasing heat-stress as well as drought-stress and together with rising extreme weather-events threaten water-balance and –supply and thus yield of crop cultivars (EITZINGER et al, 2009). Fortunately, production area is to the greatest part equipped for irrigation (NEUDORFER, 2006).

Calculations by means of INVEKOS data pool (BMLFUW, 2011b) characterize focus of crop production in Marchfeld in comparison with Lower Austria and Austrian´s total crop production. According to calculations, crop production in Marchfeld is mainly based on grain production, sugar beet and field vegetable production (see Fig. 7) focusing on onions, carrots, green peas, spinach and asparagus (NEUDORFER, 2006; BMLFUW, 2011b). Freyer et al. (2010) calculated about 44.1% of conventional production area belonging to cereals for bread, about 10-11% is planted with field vegetables and about 16% of production area belongs to sugar beet and potatoes (FREYER et al, 2010).

Agricultural structure in Marchfeld – according to INVEKOS data – is dominated by cash crop production, accounting to more than 50% of total standard gross margin of farms. Farm size is on average greater than in the rest of the country, whereby organic farms outreach conventional farms. While number of farms is declining steadily, single farm size is rising. In 2009 agricultural land was estimated to be 54,639ha with on average 58.4ha per farm, cultivated by 936 farmers (FREYER et al, 2010).

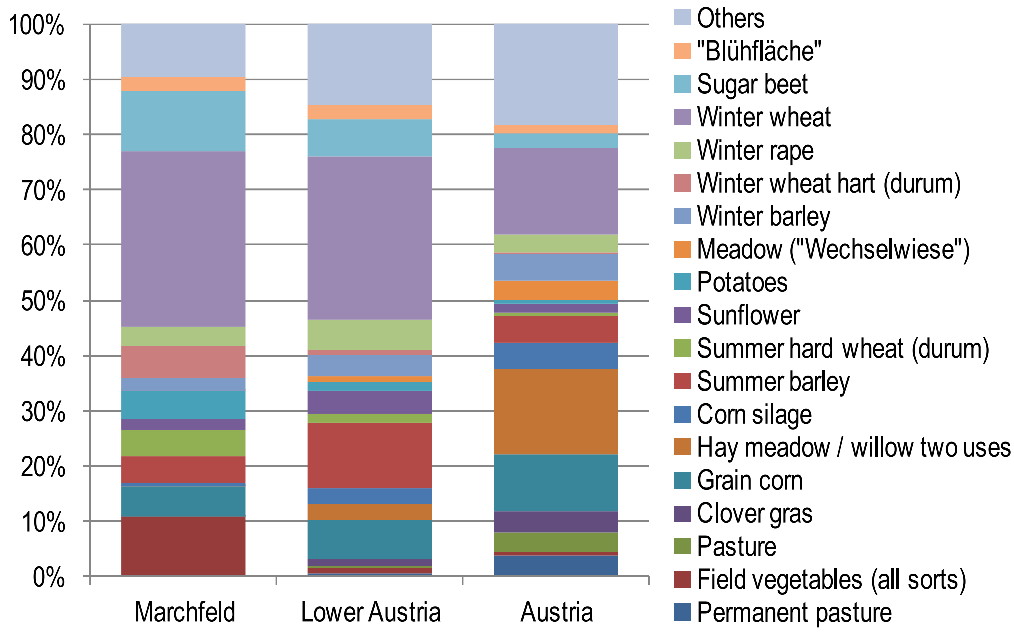


Figure 7. Percentage of area under cultivation in ha for the year 2010
Source: BMLFUW, 2011b, own calculations

According to labour rate 2011, Arbeitsmarktservice Österreich counts following enterprises to the top 10 of the biggest enterprises in the whole political district Gänserndorf:

- Iglo Austria GmbH (280 employees)
- Agrana Zucker GmbH (230 employees)
- Ideenbäcker Geier GmbH (220 employees)

In addition, food-related Raiffeisen-Lagerhaus reg. GenmbH (200 employees) and Othmar Müller GmbH (80 employees) count to the top 10 enterprises in the service sector within the district (AMS, 2011).

Unfortunately, annual reports for these enterprises and service providers are not available with the exception for the enterprise Agrana Zucker GmbH, which can be evaluated after the compliance check according to the SAFA guidelines (see FAO, 2012b, 27). The same procedure can be adapted for food retailers such as REWE and Spar, both of which publish annual reports and place them on their homepage. However, requests by phone at common supermarket chains Spar, Billa and Hofer, concerning number of contracted farmers of Marchfeld as well as sale of regional products was not successful. On the one hand, appropriate data was not available, on the other hand, data could not be handed over for reasons of data privacy.

4.2 Description of Marchfeld region according to the EASEY approach

Bearing in mind that resilient food systems tend to have short food supply chains to enable feedback loops, and that adaptation to climate change ultimately takes place at local level (GLIESSMAN, 2007; KING, 2008; INGRAM et al, 2010, 117) following dataset focuses on agricultural performance and relationship between farmers and other stakeholders most likely end-users, and is based on available, accessible data of Marchfeld region and already conducted studies:

Table 6. Indicator set according to the dimensions of the EASEY model
Sources: own collection based on PAULESICH, 2006b,32; PAULESICH, 2006a,42; CABELL and OLEOFSE, 2012

Process dimension	Stakeholder dimension	Goal dimension
Standard Output	Reasonably profitable	Securing an independent livelihood
Number of organic farms, organic production	Coupled with local natural capital (builds organic matter, low external input, safeguarding biodiversity)	Sustainable use of renewable resources
Tendency in farm number	Honors legacy	Cultural heritage, cultural diversity
Number of full-time farmers	Reasonably profitable	Securing an independent livelihood
Farms participating in tourism	Appropriately connected (with end-consumers)	Maintaining social resources, participation in social decision-making processes
Ecologically self-regulated and functional and response diversity (Field size on average, landscape elements, existence of beneficial organisms)	Habitat for Wild animals and plants, biodiversity	Sustainable use of renewable resources, safeguarding the cultural heritage of nature
Irrigation amount, irrigation practices, trends	Reasonably profitable (production costs)	Safeguarding basic provision (food security)
Socially self-organized: (presence of local action groups, LEADER regions,")	Appropriately connected to enable feedback loops	Maintaining social resources
Dominant farm type	Reasonable profitable	Securing an independent livelihood
Participation in environmental programmes	Recognition and financial compensation of environmental performance, national and regional budgets	Compensation of income and asset disparities
Emphasis of food production	Water and soil quality	Sustainable use of the environment as a sink
Diversity of food-related	Globally autonomous and	Securing an independent

Process dimension	Stakeholder dimension	Goal dimension
income sources and market access (farmers markets, community supported agriculture, farmers´shops, producer organizations, community sustainability associations, “Genuss Regionen)	locally interdependent	livelihood and at the same time safeguarding basic provision
Area of protected crops, pest management	Exposed to disturbance	Safeguarding the cultural function of nature
Agricultural price trends	Household expenditure on food	Safeguarding basic provision
Willingness and ability to innovate, innovative production	Reflective and shared learning, response diversity, collaboration between universities, consumers and farmers	Participation in social decision-making processes
Flexible design of production, contract farming	Collaboration with diverse suppliers	Participation in social decision-making processes
Standard of education of farmers, farm workers	Investment in human capital	Equality of chances

Standard Output of agricultural production

In comparison with total farms in Austria, production area Marchfeld is characterized by its high standard output, expressing the monetary value of gross agricultural production at farm-gate prizes, the economic size of the farms. Majority of production lines: cereal, sugar beet and field vegetable, is produced on farms with standard output between 65,000 and 350,000 € (see Fig. 8,9 and 10). In case of field vegetable production, percentage of farms within these production values is already about 80%, whereas for Austria, standard output does not reach 50% within these classes. However, classes with less than or equal to 3 farms cannot be included in this calculation due to data protection restrictions. Anyway, resilient market performance refers to the ability to be less dependent on subsidies or secondary employment. The indicator “standard output” together with calculations referring to operating expenditures points out if farmers are able to be roughly subsistent and make a living working on the farm.

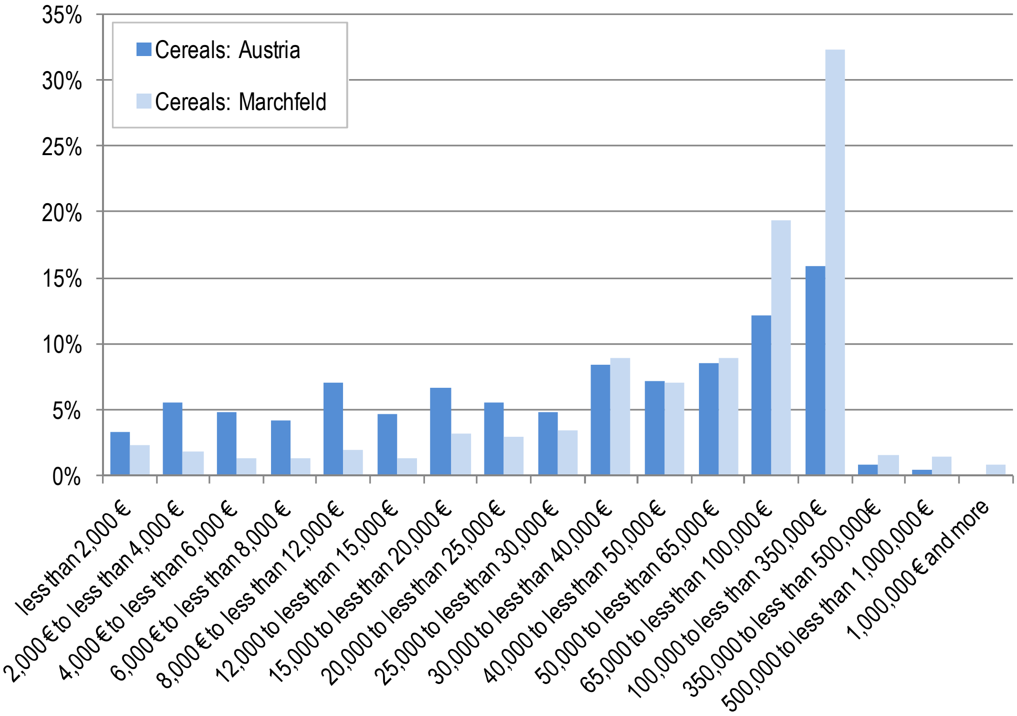


Figure 8. Relative frequency distribution of farms within standard output categories from less than 2,000 € to 1 million € and more

Source: STATISTICS AUSTRIA, 2012d

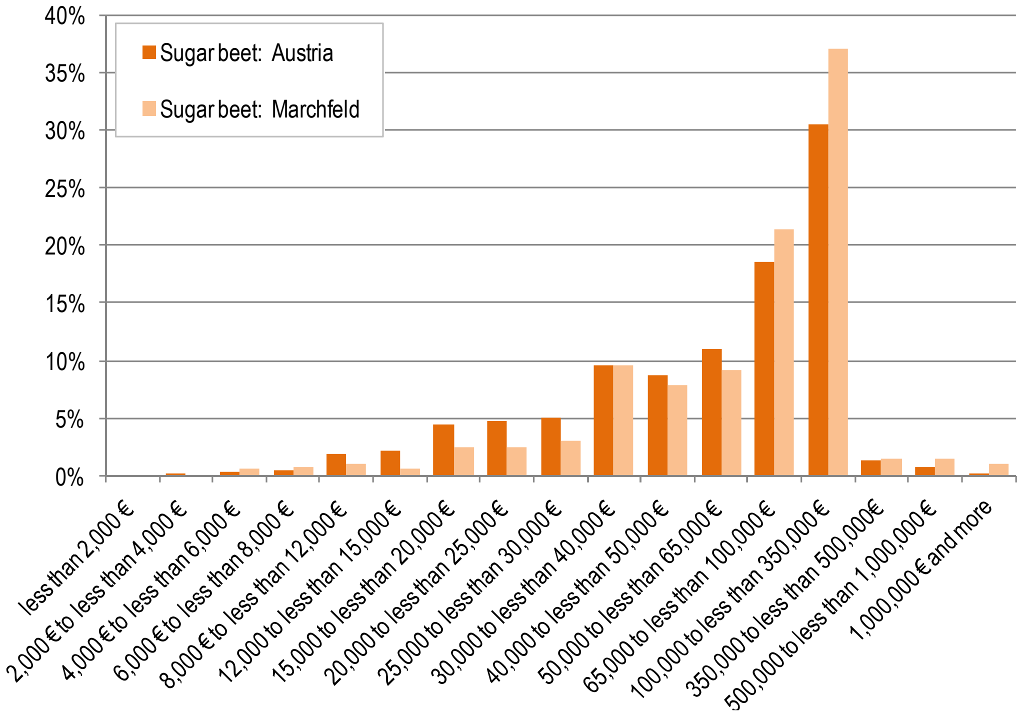


Figure 9. Relative frequency distribution of farms within standard output categories from less than 2,000 € to 1 million € and more

Source: STATISTICS AUSTRIA, 2012d

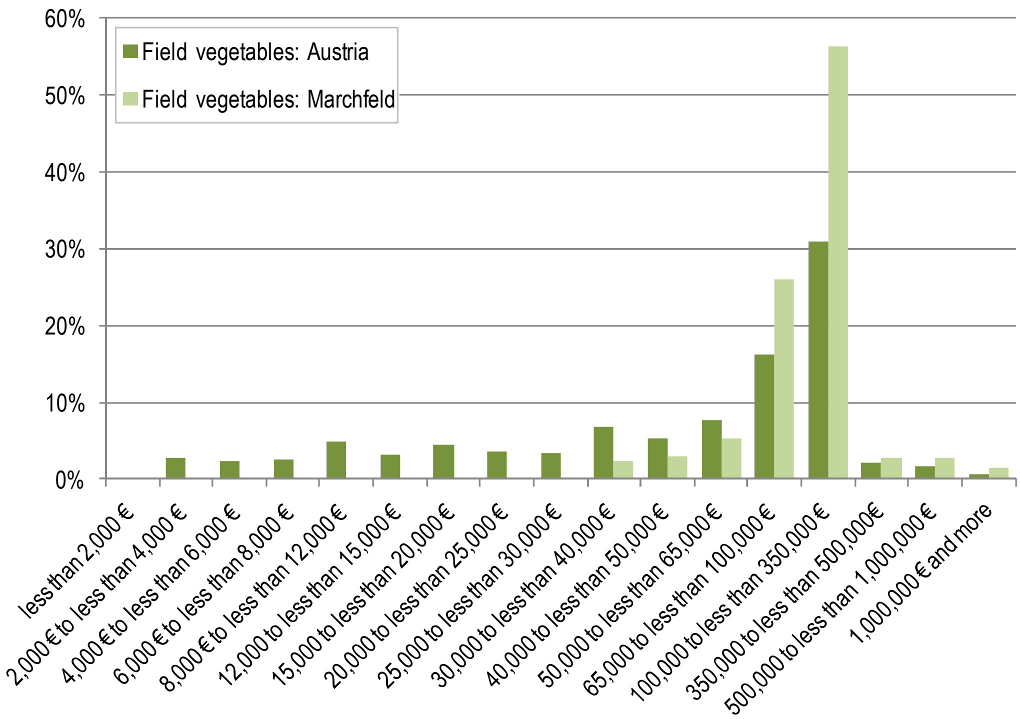


Figure 10. Relative frequency distribution of farms within standard output categories from less than 2,000 € to 1 million € and more

Source: STATISTICS AUSTRIA, 2012d

Number of organic farms

For numerous scientists, concept of organic production provides good and meaningful solutions to face challenges deriving from modern food systems and strengthens resilience of food production (DARNHOFER, 2005; GLIESSMAN, 2007; KING, 2008; FREYER et al, 2010).

In a long-term study, FREYER et al. (2010) found out that organic agriculture supports sustainable use of renewable resources, enhances biodiversity of plants and animals, improves soil quality and water storage, which is of great importance in case of climate predictions for the production area Marchfeld. Many farmers react on these and similar findings (DARNHOFER, 2005; GLIESSMAN, 2007) and on financial incentives made by the European Union and the Austrian government (BMLFUW, 2011a; BMLFUW,2012a). As a consequence, about 99% of total organic farms in Austria have been supported by the government and the European Union in 2010 (BMLFUW, 2011a, 67). High subsidies for organic production result in benefits for almost all stakeholders within the food system Marchfeld, as the new branch of economy “organic production and sale” has been established, which creates new jobs, helps to protect the environment, reconnects people and preserves the landscape (KING, 2008, FREYER et al, 2010, BMLFUW, 2010b, BMLFUW,2012a).

Annual growth rate of the number of organic farms

A comparison of Marchfeld with Austria shows that the annual growth rate of the number of organic farms between 1995 and 2010 in Marchfeld is positive throughout the whole period, whereas in the case of Austria the number of organic farms decreased in several years (see Fig. 11). Further, average growth rate for Marchfeld is increasing by 14.7% annually, while in Austria growth rate reaches only 2.2% between 1995 and 2010. However, percentage of organic farms of total farms in Marchfeld is 9.8%

in 2009 (FREYER et al, 2010,18) while for Austria organic farms count about 13.8% of total farms (STATISTICS AUSTRIA, 2012a).

In Austria total number of farms continues to decline. Especially part-time farmers tend to give up farming, while farm size is growing steadily. In 1951 Austrian average farm size was about 17.8ha, in 2010 it reaches 42.4ha (STATISTICS AUSTRIA, 2012a). Similar trends can be seen in the number of organic and conventional farms in Marchfeld (see FREYER et al, 2010, 17f), a tendency threatening cultural heritage.

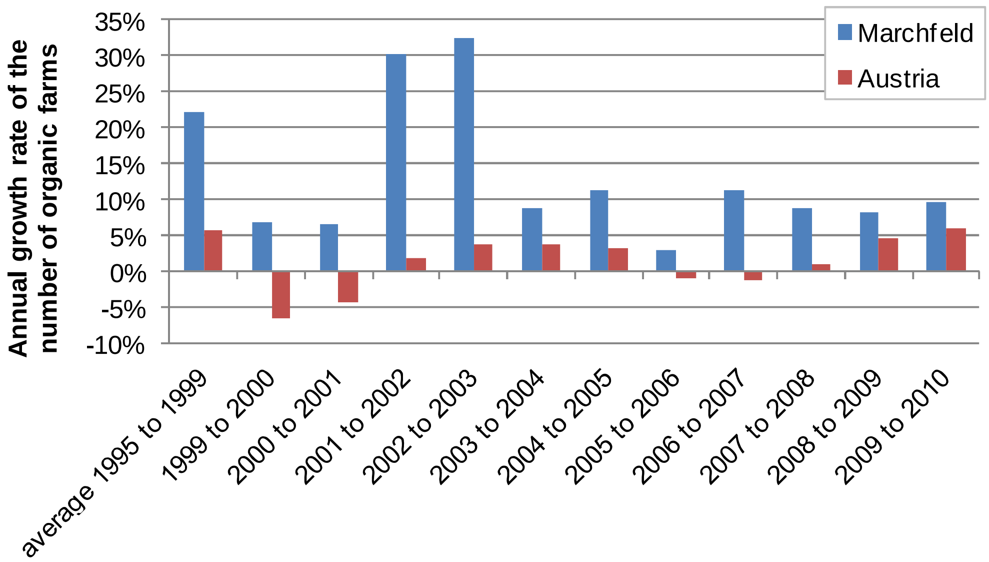


Figure 11. Annual growth rate of the number of organic farms in Austria and in Marchfeld (without districts of Vienna) from 1995 till 2010

Sources: BMLFUW, 2010a; BMLFUW, 2011a; LOWER AUSTRIAN PROVINCIAL GOVERNMENT, 2011, own calculations

Number of full-time farmers

Number of full-time farmers is declining as well. In Austria, since 1999 about 13,413 full-time farms have been given up till 2010 (STATISTICS AUSTRIA, 2012a), trends in Marchfeld are similar, but percentage of full-time farms of total farm number is still high (see Fig.12), which beneath their standard output underlines that farmers in Marchfeld are able to be reasonable profitable and subsistent with farming (STATISTICS AUSTRIA, 2012e).

Percentage of farms operating in the tourism sector

However, as tourism can help to reconnect farmers with private end-users, in Marchfeld, percentage of farms operating in the tourism sector is negligible compared with farms in environmentally sensitive, remote or mountainous regions of Austria (see Fig.13), providing opportunities to communicate in both directions needs and desires in respect to agricultural production and participation in social decision-making.

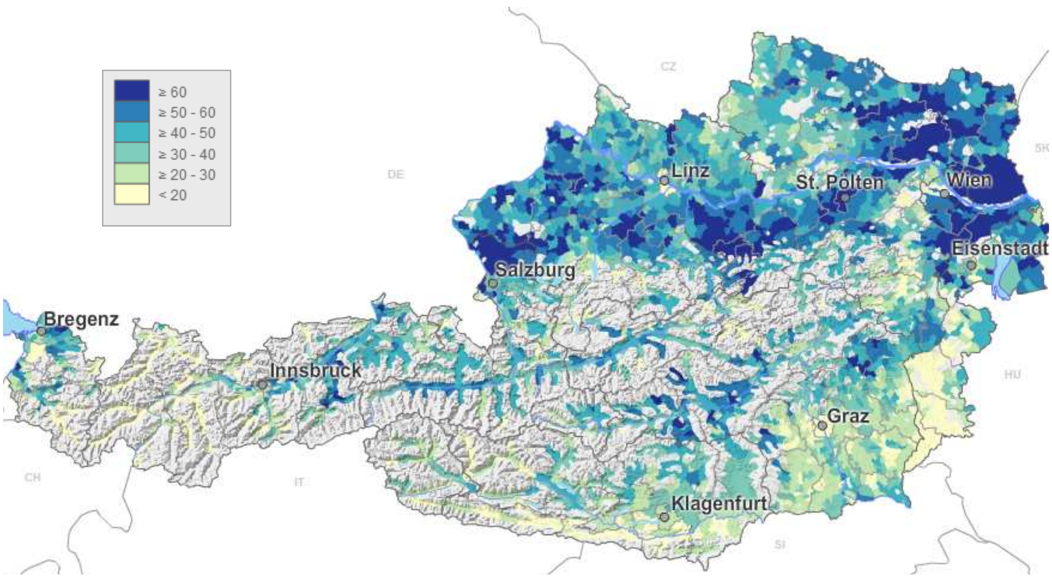


Figure 12. Percentage share of full-time farms of total farm number at community-level in 2010

Source: STATISTICS AUSTRIA, 2012e

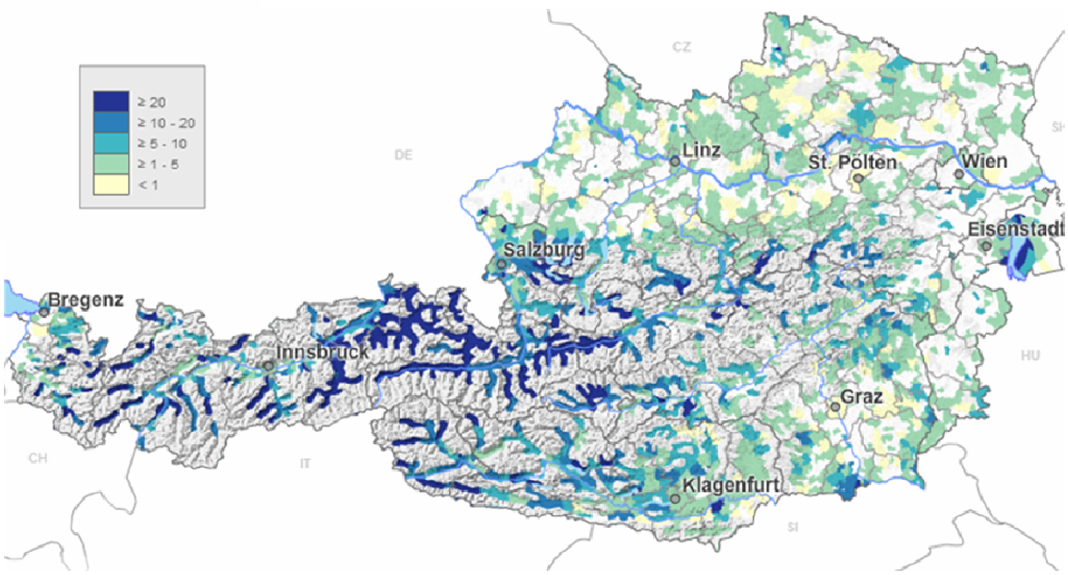


Figure 13. *Percentage of farms operating in the tourism sector of total farms*
Source: STATISTICS AUSTRIA, 2012f

Presence of a unique landscape and landscape elements

Further, agricultural production in Marchfeld is characterized by its featureless agricultural landscape and on average big field size. During the long-term study on organic farming, Freyer et al. (2010) confirm, that flowering field stripes – if existing – increases biodiversity of wild animals, beneficial organisms and wild plants, whereas landscape elements such as hedges or trees are ideal places of refuge for wild animals. Figure 7 of this thesis shows that Marchfeld is poor in meadows and permanent pasture compared to total agricultural area of Austria. As shown in figure 14, Marchfeld is also poor in forests, National Park Donau-Auen excluded, a phenomenon which goes back to unsustainable use of renewable resources in history as shown in the historical profile in chapter 3.3.3 of this thesis.

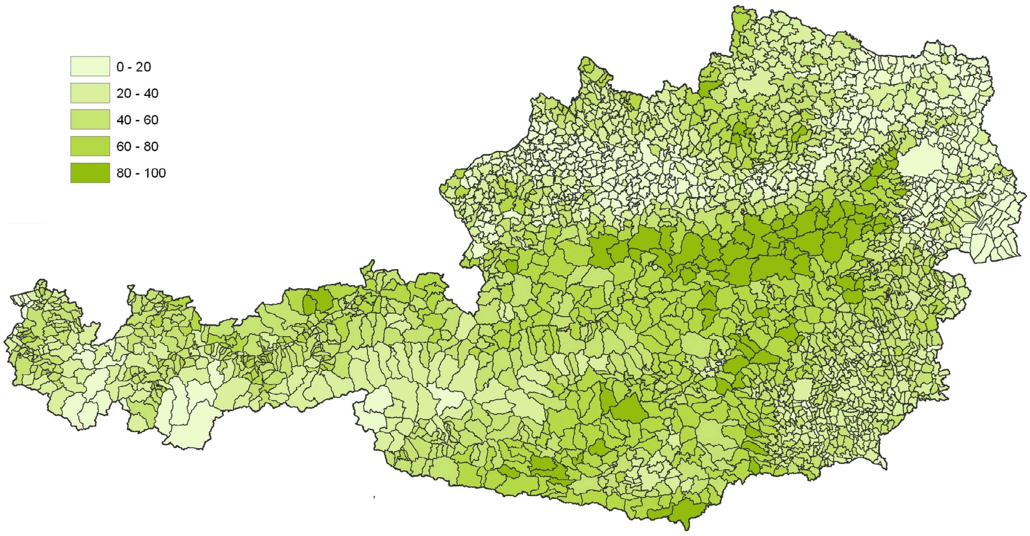


Figure 14. *Percentage of forested land of total area of the communities in 2010*
Source: BFW, 2010

Response to extreme weather events

Due to local climate situation and production emphasis, irrigation practices in Marchfeld are marked by a long history. Thus, it is not surprising that first corporate irrigation plant of Austria was constructed in Schönfeld in Marchfeld in 1953 (see historical profile, chapter 3.3.3.). However, irrigation amount is relatively high compared to Austria, because of its climatic situation (BMLFUW, 2011c). Though irrigation bears additional costs, field vegetable and sugar beet production could not be conducted without additional watering, but result in higher producer prices at the market, which again support farmers´ subsistence and provision with fresh vegetables and other agricultural products in Vienna region (STATISTICS AUSTRIA, 2012g).

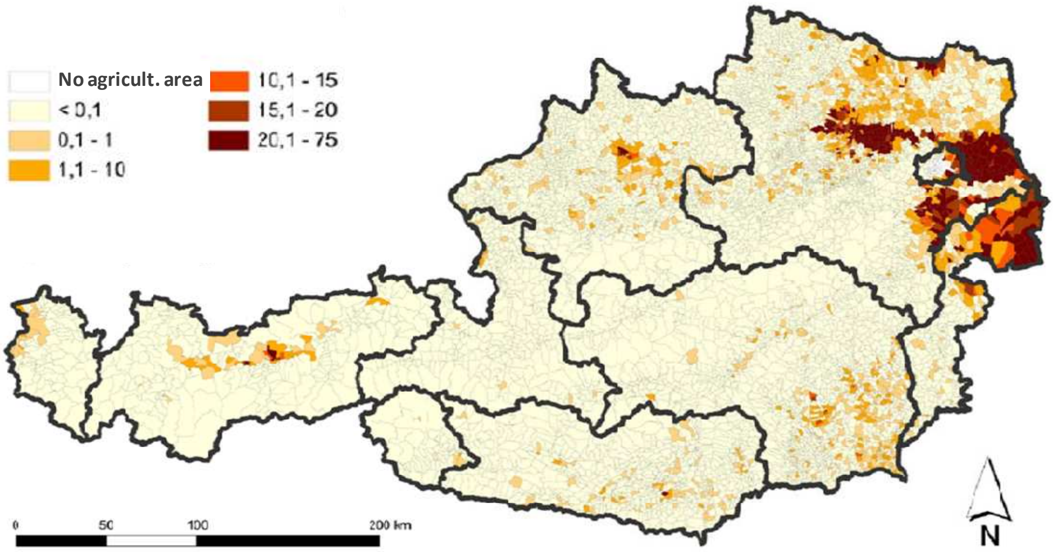


Figure 15. Percentage of irrigated agricultural area of total area of the communities in 2009
Source: BMLFUW,2011c,14

Presence of Local Action Groups

In 2008, in the course of the implementation of Community-funded rural development programmes, 86 Local Action Groups were chosen by a national selection panel. As a whole, LEADER regions are covering 88% of total area of Austria and 52% of total population of Austria. Concept of Community initiative LEADER is based on following principles: territoriality, partnership, networking, cooperation, innovation, multi-sectorality and the use of the bottom-up approach, enabling feedback loops while strengthening social resources. Projects within each local action group aimed at improving relationships between local actors, different local economic sectors and thus improving local economic power but also quality of rural life (DAX et al, 2011). According to the following illustration, it is obvious that "LEADER Region Marchfeld" accounts for the most engaged local action groups in Austria (BMLFUW, 2010c). Most recent project of LEADER Region Marchfeld is dedicated to extreme climatic events, namely extraordinary high precipitation amounts since 2006, which resulted in high groundwater level and local flooding of cellars. LEADER Region Marchfeld initiated successfully ground-water aid for about 500 buildings within the Marchfeld Region (REGION MARCHFELD, 2011).

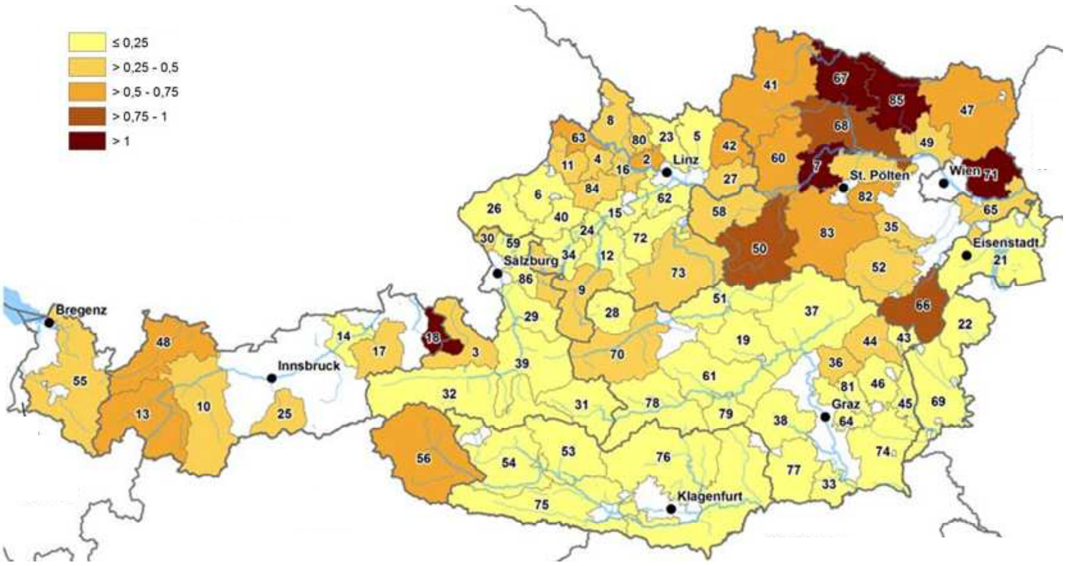


Figure 16. Distribution of LEADER projects of LAG per 1000 inhabitants in LAG for the period 2007-2009

Source: BMLFUW, 2010c,528

Participation in environmental programmes

Participation in environmental programmes in Marchfeld is relatively high. In case of conventional farming, Freyer et al. (2010) calculated for the year 2009 that nearly 95% of total area belonging to the agricultural holdings can be assigned to the measure “Environmentally friendly management of arable land and grass land”, more than 41% take part in the measure “protection of water and soil” and more than 34% participate in “greening of arable land”. Further, more than 71% of total area belonging to the organic agricultural holdings take part in the measure “organic farming” and get financial compensation for environmental performances (FREYER et al, 2010). Table 7 presents participation in ÖPUL measures as percentage of total farms in Austria and as percentage of total area belonging to the agricultural holdings of Marchfeld. Though, direct comparison of data is not possible – due to different criteria and lack of available prepared data, participation of Marchfeld farms can be seen as extraordinary high.

In addition, several environmental measures were analyzed concerning its effects on climate change mitigation. ÖPUL measures “Organic farming”, “Renunciation of yield-increasing inputs on arable land” and “Greening of arable land” resulted in a superior greenhouse gas balance. Responsible for these effects seem to be the use of organic fertilizers and greening, both seem to increase share of hummus in the soil (FREUDENSCHUß et al, 2010)

Table 7. Participation in several ÖPUL measures in % of total farms respectively total farm area

Source: FREYER et al, 2010; STATISTICS AUSTRIA, 2012a; HÖLZL, 2012

	Austria Participation in ÖPUL measures in % of total farms (2010)	**Marchfeld** Share of total area belonging to agricultural holdings participating in the ÖPUL measures (2009)
Organic farming	98%	72%
Environmentally friendly management of arable land and grass land	39%	95%
Greening of arable land	29%	34%
Soil and water protection	3%	41%
Mulch and direct sowing	9%	16%

Diversity of food-related income sources and market access

„Genuss Region Österreich“ is a registered trademark founded by Agrarmarkt Austria Marketing GmbH and the Federal Ministry of Agriculture, Forestry, Environment and Water Management to visualize regional culinary specialities to enhance regional economic power. In 2011, about 110 “Genuss Regionen” have been marketed in Austria, including “Marchfeld Gemüse” and “Marchfeldspargel g.g.A”, created by vegetable farmers of Marchfeld (BMLFUW,2012b). Establishing “Genuss Regionen” exemplifies ability to innovate, to be flexible and at the same time is a good example for successful collaboration between governmental institutions, marketing platforms and farmers. Further marketing highlights respectively innovative means of distribution within production area Marchfeld can be mentioned concerning organic production. Organic farm “Adamah” provides fruit and vegetables boxes by delivery service for Vienna Region (ADAMAH, 2012), while organic farm “Ochsenherz” offers a partnership between 200 end-users and local vegetable producers after the concept of Community Supported Agriculture. (OCHSENHERZ, 2012).

4.3 Conclusion

The production area Marchfeld belongs to the most frequently analyzed social-ecological systems in Austria. Despite digitalization of numerous studies, statistics and meaningful records, accessibility to appropriate data is challenging and requires time-consuming desk research and in some cases direct contact with responsible authorities as data are reserved for pertinent scientific research to avoid misuse. However, it was finally possible to obtain, pool and analyze economic, social and environmental parameters for the production area Marchfeld.

In setting up a historical profile of the whole region, a basis for further research was created, which reveals strengths and weaknesses of the region and most importantly trigger events, leading to a significant change of regional characteristics, which further influences resilience. In addition, relevant scientific studies on Marchfeld were collected and the main results summarized. A set of indicators was defined on the basis of the EASEY approach and the behavior based indicators elaborated by Cabell and Oleofse (2012). For these indicators a comparison between the Marchfeld Region and Austria was carried out.

Following the three dimensions of sustainable development, these indicators include economic, social and environmental aspects with a focus on agricultural production. Bearing in mind what resilient food systems should look like, food system Marchfeld can be described as economically successful, environmentally engaged and socially connected.

However, suitable indicators for food processing and retailing could not be generated as adequate data were not available and indicators on a purely normative basis are less meaningful to assess actual sustainability performance.

Nevertheless, indicator set of the EASEY model is suitable to reflect major characteristics of the Marchfeld region and its impact on the major stakeholders: farmers, clients, society, donors, market and environment. Especially, impact on farmers and end-users can be highlighted within the generated data set.

Hence, a case study for the applicability of the EASEY model on certain regions has been successfully carried out. Marchfeld is a well-established production area and of special interest for scientific researchers due to its climatic situation and proximity to the sales market Vienna Region. It is concluded that the application of the EASEY approach on a certain region is possible if adequate data are available. If this is not the case and data need to be generated first, the approach is considered resource-intensive and challenging.

With regard to climate change, historical extreme weather events resulted in a high readiness to respond to adverse conditions. Marchfeld is largely equipped for irrigation and is participating in greening of arable land to avoid soil erosion by strong windy conditions. Furthermore, the region has proven to be socially self-organized, as for example local initiatives to combat flooding during heavy rain falls have shown.

4.4 Discussion

Resilience assessments of social-ecological systems are used to be resource- and time-consuming by nature for the simple reason that social-ecological systems are complex and dynamic and therefore frequently exposed to change and disturbance. As a consequence, evaluation requires sound knowledge of interactions within the system to deliver suitable results for local decision makers. Further, analyses need to be updated frequently to enable a timely response to adverse events.

Food systems contribute to food security and human health but also to environmental security as food systems are highly dependent on natural resources.

According to the Food and Agriculture Organisation (FAO) about 925 million people in the world are estimated to be undernourished in 2010, mainly in Asia, the Pacific and Sub-Saharan Africa while global food production as well as consumption is still growing. Though the estimated total number of undernourished people spiked in 2009, as a result of the world food price crisis, the financial crisis and economic recession, food prices are slowly declining, but remain higher than before the shocks and are projected to increase over the next 10 years due to higher production costs, rising demand, upcoming biofuel production and market speculations and will together with existing or emerging natural and human-induced disasters challenge food security and hunger-reduction efforts (FAO, 2011a; FAO, 2011b).

For that reason, establishing and supporting resilient food systems is in everyone´s interest. Participation of science in food systems development needs to be promoted and findings of complex interrelationships along the food value chain mediated correspondingly, to reach relevant stakeholders and public interest.

As this food system assessment by means of the EASEY model focused on literature and data research, next step will be to engage local stakeholders – a lesson learned from the MA approach, to foster group discussions and to enable and promote feedback-loops and at the same time adjust set of indicators to make the best use of scientific research.

5 Summary

The concept of resilience is increasingly being used to assess sustainability of social-ecological systems in case of disturbances or threats with the focus on adaptability, buffer capacity and self-organisation.

In the context of an interdisciplinary research project “Climate Change and Regional Sustainability” between the University of Vienna, Department of Nutritional Sciences and the Vienna University of Economics and Business Administration, Institute for Regional- and Environmental Economics and Management, resilience of food production area Marchfeld with respect to climate change was analyzed by means of the integrative model EASEY, which was formerly developed to visualize sustainability performance of companies quoted on the stock exchanges.

Via comprehensive literature research on the food system Marchfeld and frequently conducted group discussions within the project staff, the EASEY model was basically adjusted for regional assessments. Within this thesis, the single dimensions of EASEY, namely process-, stakeholder- and goal dimension were put in concrete terms. Further, a new set of economic, social and ecological indicators was developed, based on already existing indicators of EASEY, behaviour-based indicators from literature- which allow less precise metrics but comprehensive analysis – and indicators, derived from data research.

By means of these indicators, situation in Marchfeld was compared with condition in Austria and then resilience of the food production area Marchfeld evaluated. Results clearly indicate that agricultural food production in Marchfeld is characterised by innovative, adaptive and profitable land-use management and can widely be termed resilient in case of climate change due to the possibility of irrigation and attributes mentioned before.

6 Zusammenfassung

Das Konzept der Resilienz gewinnt an Akzeptanz und wird zunehmend in sozial-ökologischen Studien angewendet um die Anpassungsfähigkeit, die Pufferfähigkeit und die Lernfähigkeit der im System befindlichen Akteure unter sich ändernden Rahmenbedingungen zu analysieren.

Im Rahmen des interdisziplinären Forschungsprojektes „Klimawandel und regionale Nachhaltigkeit" zwischen der Universität Wien, Department für Ernährungswissenschaften und der Wirtschaftsuniversität Wien, Institut für Regional- und Umweltwirtschaft wurde die Resilienz des landwirtschaftlichen Kleinproduktionsgebietes Marchfeld in Hinblick auf den Klimawandel untersucht. Dabei wurde das integrative Nachhaltigkeitsmodell EASEY verwendet, welches ehemals für die Nachhaltigkeitsleistung börsennotierter Unternehmen entwickelt wurde.

Mittels umfassender Literaturrecherche zur Lebensmittelwirtschaft im Marchfeld und auf der Basis von regelmäßig durchgeführten Gruppendiskussionen innerhalb der Forschungsgruppe wurde das EASEY Modell grundlegend an die Bedürfnisse regionaler Untersuchungen angepasst. In dieser Diplomarbeit wurde näher auf die drei Dimensionen „Prozesse", „Anspruchsgruppen" und „Ziele" des EASEY Modells eingegangen und die Bezugsquellen konkretisiert. In weiterer Folge wurde ein neuer Satz von wirtschaftlichen, sozialen und ökologischen Indikatoren entwickelt, der auf die bereits vorhandenen Indikatoren des EASEY Modells zurückgreift, diese jedoch passend zur Bedarfslage durch Indikatoren aus der lokalen Datenrecherche sowie mit verhaltensbezogenen Indikatoren aus der Literatur ergänzt.

Anschließend konnte die Situation der Marchfelder Lebensmittelwirtschaft anhand des Datensatzes beleuchtet und mit passenden Daten für Österreich verglichen werden. Die Ergebnisse weisen deutlich darauf hin, dass die Lebensmittelproduktion im Marchfeld profitabel, innovativ gestaltet und den wirtschaftlichen, gesellschaftlichen und ökologischen

Herausforderungen gewachsen ist. Daher und aufgrund der bereits durchgeführten Anpassungsmaßnahmen (nicht zuletzt der beinahe flächendeckend vorhandenen Bewässerungssysteme) kann die Region hinsichtlich des Klimawandels derzeit als weitgehend resilient bezeichnet werden.

7 References

ADAMAH. Lebendiger Boden – Gelebte Vielfalt – Gesunde Lebensmittel. Adamah, 2012. online [URL]: http://www.adamah.at/biohof-adamah.html (accessed 11 09 2012)

ADGER WN, HUGHES TP, FOLKE C, CARPENTER SR, ROCKSTRÖM J. Social-ecological resilience to coastal disasters. Science 2005, 309: 1036-1039.

ADGER WN. Social and ecological resilience: are they related? Progress in Human Geography 2000, 24 (3). 347-364

AGRANA: Von der Rübe zum Wiener Zucker. Facts and figures 2011, Agrana, 2011. online [URL]: http://www.agrana.com/fileadmin/inhalte/agrana_group/folders%20and%20brochures/Von_der_R%C3%BCbe_zum_Wiener_Zucker_2011.pdf (accessed 20 08 2012)

ALBRITTON DL, ALLEN MR, BAEDE APM, CHURCH JA; CUBASCH U et al. Summary for policy makers. In: Climate Change 2001: The scientific basis. Contributions of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, (HOUGHTON JH, ed). Cambridge University Press, Cambridge, United Kingdom, 2001, 21-98

ALLEY RB, BERNTSEN T, BINDOFF NL, CHEN Z, CHIDTHAISONG A et al. Summary for policymakers. In: Climate Change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (SOLOMON S, QIN D, MANNING M, MARQUIS M, AVERYT KB et al, eds). Cambridge University Press, Cambridge, United Kingdom and New York, USA, 2007

ALLISON I, BINDOFF NL, BINDSCHADLER RA, COX PM, DE NOBLET N et al. The Copenhagen Diagnosis, 2009: Updating the World on the latest Climate Science. The University of New South Wales Climate Research Centre, Sydney, Australia, 2009

AMS (Arbeitsmarkt Service). Arbeitsmarktprofil 2011. Gänserndorf. Betriebsmonitoring. Arbeitsmarktservice Österreich, 2011 online [URL]: http://www.arbeitsmarktprofile.at/2011/308/teil_04.html (accessed 05 09 2012)

ANDERL M, FREUDENSCHUß A, FRIEDRICH A, HAIDER S, JOBSTMANN H et al. Austria´s National Inventory Report 2012. Submission under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol. Umweltbundesamt GmbH, Vienna, 2012

BENNETT EM, CUMMING GS, PETERSON GD. A systems model approach to determining resilience surrogates for case studies. Ecosystems 2005; 8: 945-957

BFW (Bundesforschungs- und Ausbildungszentrum für Wald, Natur und Landschaft). Waldanteil der Gemeinden in Österreich, BFW, 2010. online [URL]: http://bfw.ac.at/020/wi/nrkarten/dl/bund_bewaldungsprozent.zip (accessed 05 09 2012)

BIGGS R, BOHENSKY E, DESANKER PV, FABRICIUS C, LYNAM T et al. Nature supporting people. The Southern African Millennium Ecosystem Assessment. Integrated report: Council for Scientific and Industrial Research, Pretoria, South Africa, 2004

BMLFUW (Austrian Federal Ministry of Agriculture, Forestry, Environment and Watermanagement). Grüner Bericht 2010. Bericht über die Situation der österreichischen Land- und Forstwirtschaft. BMLUFW, Vienna, 2010a

BMLFUW (Austrian Federal Ministry of Agriculture, Forestry, Environment and Watermanagement). Grüner Bericht 2011. Bericht über die Situation der österreichischen Land- und Forstwirtschaft. BMLUFW, Vienna, 2011a

BMLFUW (Austrian Federal Ministry of Agriculture, Forestry, Environment and Watermanagement). Lebensmittelbericht Österreich 2010. BMLFUW, Vienna, 2010b

BMLFUW (Austrian Federal Ministry of Agriculture, Forestry, Environment and Watermanagement): written electronic message to Oepul measurements, INVEKOS data, 2011b

BMLFUW (Austrian Federal Ministry of Agriculture, Forestry, Environment and Watermanagement). Bewässerte Flächen in Österreich. Evaluierung des Programms LE07-13 "Abschätzung der bewässerten und bewässerungsbedürftigen landwirtschaftlichen Flächen sowie Integration der Daten in die INVEKOS-Datenbank". Final report, version 2.0, 2011c [online] URL: http://www.lebensministerium.at/dms/lmat/land/laendl_entwicklung/evaluierung/le_studien/flaechen/39_Bew-sserung-lw-Fl-Endbericht/39_Bew%C3%A4sserung%20lw%20Fl%20Endbericht.pdf (accessed 01 09 2012)

BMLFUW (Austrian Federal Ministry of Agriculture, Forestry, Environment and Watermanagement). Österreichisches Programm für die Entwicklung des Ländlichen Raums 2007-2013, Federal Ministry of Agriculture, Forestry, Environment and Watermanagement, Vienna, 2012a

BMLFUW (Austrian Federal Ministry of Agriculture, Forestry, Environment and Watermanagement). Evaluierungsbericht 2010. Halbzeitevaluierung des Österreichischen Programms für die Entwicklung des ländlichen Raums, Federal Ministry of Agriculture, Forestry, Environment and Watermanagement, Vienna, 2010c

BMLFUW (Austrian Federal Ministry of Agriculture, Forestry, Environment and Watermanagement).Genuss Region Österreich: Die Initiative. BMLFUW,2012b. [online] URL: http://www.genuss-region.at/article/archive/8820 (accessed 17 08 2012)

BOHENSKY E, REYERS B, VAN JAARSVELD AS, FABRICIUS C. Ecosystem services in the Gariep Basin. A contribution to the Millennium Ecosystem Assessment, prepared by the Gariep basin team of SAfMA, the Southern African Millennium Ecosystem Assessment. SUN PReSS, Stellenbosch 7600, South Africa, 2004. [online] URL: http://www.maweb.org/documents_sga/SAfMA_Gariep_Basin_non-printable.pdf (accessed 06.05.2012)

BÖHM R, GODINA R, NACHTNEBEL HP, PIRKER O, RANDL F et al. Auswirkungen des Klimawandels auf die österreichische Wasserwirtschaft, BMLFUW and ÖWAV, Vienna, 2008; 204. [online] URL: http://www.zamg.ac.at/histalp/downloads/abstract/Boehm-2008b-F.pdf (accessed 22 06 2012)

BRAND FS and JAX K: Focusing the meaning(s) of resilience: resilience as a descriptive concept and a boundary object. Ecology and Society 2007, 12:23. [online] URL: http://www.ecologyandsociety.org/vol12/iss1/art23/ES-2007-2029.pdf (accessed 15 07 2012)

CABELL JF, OELOFSE M. An indicator framework for assessing agroecosystem resilience. Ecology and Society 2012; 17: 18. [online] URL: http://www.ecologyandsociety.org/vol17/iss1/art18/ES-2012-4666.pdf (accessed 08.06.2012)

CARPENTER S, WALKER B, ANDERIES JM, ABEL N. From metaphor to measurement: resilience of what to what? Ecosystems 2001,4:765-781

CASSMAN KG, WOOD S, CHOO PS, COOPER HD, DEVENDRA C et al. Chapter 26. Cultivated Systems. In: Ecosystems and human well-being: Current state and trends. Findings of the condition and trends working group of the Millennium Ecosystem Assessment (HASSAN R, SCHOLES R., ASH N, ed) Island Press, Washington/Covelo/London, 2005, 745-794. online [URL]: http://www.maweb.org/documents/document.295.aspx.pdf (accessed: 05.05.2012)

DARNHOFER I, BELLON S, DEDIEU B, MILESTAD R. Adaptiveness to enhance the sustainability of farming systems. A review. Agron. Sustain. Dev., 2010; 30: 545-555

DARNHOFER I, LINDENTHAL T, ZOLLITSCH W, BARTEL-KRATOCHVIL R. Konventionalisierung: Notwendigkeit einer Bewertung mittels Indikatorensystem, basierend auf den IFOAM-Prinzipien. In: Werte – Wege – Wirkungen: Biolandbau im Spannungsfeld zwischen Ernährungssicherung, Markt und Klimawandel. *Beiträge zur 10.* Wissenschaftstagung Ökologischer Landbau (MAYER J, ALFOELDI T, LEIBER F, DUBOIS D, FRIED P et al, ed), Dr. Köster, Berlin, 2009; 514-517

DARNHOFER I, MILESTAD R. Fördert der biologische Landbau die Resilienz landwirtschaftlicher Betriebe? Ländlicher Raum, 2003;28-30. [online] URL: http://www.lebensministerium.at/dms/lmat/land/laendl_entwicklung/Online

-Fachzeitschrift-Laendlicher-Raum/archiv/2003/darnhofer/Darnhofer_endend-1-/Darnhofer_endend%5B1%5D.pdf (accessed 09 09 2012)

DARNHOFER I. Resilienz und die Attraktivität des Biolandbaus für Landwirte. In: Bio-Landbau in Österreich im internationalen Kontext. Zwischen Professionalisierung und Konventionalisierung. (GROIER M, SCHERMER M, ed) Forschungsbericht 55, Bundesanstalt für Bergbauernfragen, Vienna, 2005; 67-84

DAX T, OEDL-WIESER T, STRAHL W. Halbzeitbewertung der LEADER-Maßnahmen. Österreichisches Programm für die Entwicklung des Ländlichen Raums 2007-2013, interim report, Bundesanstalt für Bergbauernfragen, Vienna, 2011. [online] URL: http://www.berggebiete.at/cms/dmdocuments/publikationen/FF47.pdf (accessed 10 09 2012)

DIE RÜBENBAUERN. Entwicklung des Österreichischen Zuckerrübenanbaus. Die Rübenbauern, 2002. Online [URL]: http://www.ruebenbauern.at/uebersicht/entwicklung/ (accessed 08 0 2012)

EAKIN HC, WEHBE MB. Linking local vulnerability to system sustainability in a resilience framework: two cases from Latin America. Climatic Change 2009; 93: 355-377

EEA (European Environmental Agency): Impacts of Europe's changing climate — 2008 indicator-based assessment. Joint EEA-JRC-WHO report, EEA, Copenhagen, Denmark, 2008, 37-75. [online] URL: http://www.eea.europa.eu/publications/eea_report_2008_4/pp37-75CC2008_ch5-1to4_Athmosphere_and-_cryosphere.pdf (accessed 14 06 2012)

EITZINGER J, KERSEBAUM KC, FORMAYER H. Landwirtschaft im Klimawandel. Agrimedia GmbH, First Edition, Germany, 2009

ERICKSEN PJ. Conceptualizing food systems for global environmental change research. Global Environmental Change 2008,18: 234 – 245.

ERZEUGERORGANISATION MARCHFELDGEMÜSE. Gesellschafter. [online] URL: http://www.eom.at/beteiligte.html (accessed 02 08 2012)

EVANS A. Governance for a resilient food system. Oxfam discussion papers, Oxfam international, New York, 2011, [online] URL: http://www.oxfam.org/sites/www.oxfam.org/files/dp-governance-resilient-food-system-010611-en.pdf (accessed 15 07 2012)

FAO (Food and Agriculture Organization). The state of food and agriculture 2010 – 2011. FAO 2011a, Rome, Italy, [online] URL: http://www.fao.org/docrep/013/i2050e/i2050e.pdf (accessed 05 06 2012)

FAO (Food and Agriculture Organization). Trade reforms and food security. Conceptualizing the linkages. FAO 2003, Rome, Italy

FAO (Food and Agriculture Organization) World agriculture: Towards 2030/2050. Prospects for food, nutrition, agriculture and major commodity groups. Interim Report. FAO, Rome, 2006

FAO (Food and Agriculture Organization of the United Nations). Global hunger declining but still unacceptably high. International hunger targets difficult to reach. FAO,2010. online [URL]: http://www.fao.org/docrep/012/al390e/al390e00.pdf (accessed 20 07 2012)

FAO (Food and Agriculture Organization of the United Nations), International Fund for Agricultural Development (IFAD), Organization for Economic Cooperation and Development (OECD), World Bank, UN High-Level Task Force on the Global Food Security Crisis et al. Price volatility in food and agricultural markets: policy responses. OECD, Paris. 2011b; 7. [online] URL: http://www.fao.org/fileadmin/templates/est/Volatility/Interagency_Report_to_the_G20_on_Food_Price_Volatility.pdf (accessed 22 08 2012)

FAO (Food and Agriculture Organization of the United Nations). Sustainability Assessment of Food and Agriculture Systems (SAFA). Guidelines. Test Version 1.0, FAO, Rome, 2012b. [online] URL: http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/SAFA_Guidelines_12_June_2012_final_v2.pdf (accessed: 27.07.2012)

FAO (Food and Agriculture Organization). Land resources. AEZ - Agro-ecological Zoning System, FAO 2012a, [online] URL: http://www.fao.org/nr/land/databasesinformation-systems/aez-agro-ecological-zoning-system/en/ (accessed: 16.07.2012)

FISCHER G, SHAH M, TUBIELLO FN, VAN VELTHUIZEN H. Socio-economic and climate change impacts on agriculture: an integrated assessment, 1990-2080, Phil Trans. R. Soc. B 2005, 360. 2067 –2083

FISCHER G.; SHAH M.; VAN VELTHUIZEN, H. Climate Change and Agricultural Vulnerability.Special report. Remaprint, Vienna, 2002

FLETCHER CS, CRAIG M, HILBERT DW. Operationalizing resilience in Australian and New Zealand Agroecosystems. Proceedings of the 50th annual meeting of the International Society for the Systems Sciences (ISSS), ISSS, California, 2006

FOLKE C, CARPENTER S, ELMQUIST T, GUNDERSON L, HOLLING CS et al. Resilience and sustainable development: Building adaptive capacity in a world of transformation. Edita Norstedts Tryckeri AB, Stockholm, 2002. online [URL]: http://www.sou.gov.se/mvb/pdf/resiliens.pdf (accessed 05 05 2012)

FREUDENSCHUß A, SEDY K, ZETHNER G, SPIEGEL H. Arbeiten zur Evaluierung von ÖPUL-Maßnahmen hinsichtlich ihrer Klimawirksamkeit. Schwerpunkt agrarische Bewirtschaftung. Umweltbundesamt GmbH, Vienna, 2010

FREYER B, SURBÖCK A, HEINZINGER M, FRIEDEL JK, SCHAUPPENBERGER T et al. Evaluierung LE07-13. Bewertung des viehlosen biologischen Ackerbaus und seiner agrarökologischen Leistungen im österreichischen Trockengebiet., interim report, Austrian Federal Ministry of Agriculture, Forestry, Environment and Watermanagement, Vienna, 2010

GALLOPIN CP. Linkages between vulnerability, resilience and adaptive capacity. Global environmental change 2006, 16: 293 – 303

GLIESSMAN SR. The need for sustainable food production systems. In: Agroecology: The ecology of sustainable food systems. Second edition (GLIESSMAN SR, ed) CRC Press. Taylor & Francis Group, New York, 2007; 3-21

HAMEL G, VÄLINKANGAS L. The quest for resilience. Harvard Business Review 2003, 81:52-65

HASSAN R, SCHOLES R, ASH N. Chapter 1. MA Conceptual framework. In: Ecosystems and human well-being: Current state and trends. Findings of the condition and trends working group of the Millennium Ecosystem Assessment (HASSAN R, SCHOLES R., ASH N, ed). Island Press, Washington/Covelo/London, 2005, 25-36. online [URL]: http://www.maweb.org/documents/document.765.aspx.pdf (accessed 05.05.2012)

HAWKES C, RUEL MT. Value chains for nutrition. 2020 Conference Paper 4, prepared for the IFPRI 2020 international conference “Leveraging agriculture for improving nutrition and health”, New Delhi, India, 2011. online [URL]:http://www.ifpri.org/sites/default/files/publications/2020anhconfpaper04.pdf (accessed 09 06 2012)

HOLLING CS. Resilience and stability of ecological systems. Annual review of ecology and systematic 1973, 4: 1-23

HOLLING CS. Simplifying the complex: the paradigms of ecological function and structure. European Journal of Operatioinal Research 1987, 30: 139-146

HÖLZL FX. Akzeptanz von ÖPUL-Maßnahmen in der Praxis. 3.Umweltökologisches Symposium Lfz Raumberg-Gumpenstein. Landwirtschaftskammer Oberösterreich, 2012.

HOUSE J, BROVKIN V, BETTS R, CONSTANZA B, SILVA DIAS MA et al. Chapter 13. Climate and Air Quality. In: Ecosystems and human well-being: Current state and trends. Findings of the condition and trends working group of the Millennium Ecosystem Assessment (HASSAN R, SCHOLES R., ASH N, ed). Island Press, Washington/Covelo/London, 2005, 355-390. online [URL]: http://www.maweb.org/documents/document.282.aspx.pdf (accessed 05.05.2012)

INGRAM J, ERICKSEN P, LIVERMAN D. Food security and global environmental change, Earthscan, London/Washington DC, 2010; [online] URL: http://www.gecafs.org/publications/Publications/Food_Security_and_Global_Environmental_Change.pdf (accessed 01.07.2012).

IGLO: Geschichte Iglo, 2012. [online] URL: http://www.iglo.at/uploads/media/Geschichte_Iglo_Booklet_Jaenner_2012.pdf (accessed 02 08 2012)

KING CA. Community resilience and contemporary agri-ecological systems: Reconnecting people and food and people with people. Systems Research and Behavioral Science 2008; 25: 111-124

KOOHAFKAN P, ALTIERI MA, HOLT GIMENEZ E. Green agriculture: foundations for biodiverse, resilient and productive agricultural systems. International Journal of Agricultural Sustainability 2012; 10: 61-75

KOPFMÜLLER J, BRANDL V, JÖRISSEN J, PAETAU M, BANSE G et al. Nachhaltige Entwicklung integrativ betrachtet – Konstitutive Elemente, Regeln, Indikatoren, edition sigma, Berlin, 2001

KROMP-KOLB H, FORMAYER H, EITZINGER J, THALER S, KUBU G et al. Potentielle Auswirkungen und Anpassungsmaßnahmen der Landwirtschaft an den Klimawandel im Nordosten Österreichs (Weinviertel-Marchfeld Region). In: Auswirkungen des Klimawandels in Niederösterreich. (FORMAYER H, ed). 2008; 96-140. [online] URL: http://www.noel.gv.at/bilder/d33/NOE_Klimastudie_2007.pdf?13263 (accessed 16 06 2012)

LAGERHAUS MARCHFELD. Geschichte Lagerhaus Marchfeld. Raiffeisen Lagerhaus Marchfeld reg GenmbH, 2003. [online] URL: http://www.lagerhaus-marchfeld.at/?id=2500%2C1197968%2C%2C (accessed 20 08 2012)

LANDESMUSEUM NIEDERÖSTERREICH. Chronik. [online] URL: http://geschichte.landesmuseum.net/index.asp?contenturl=http://geschichte.landesmuseum.net/chronik/chronik_results.asp___begriff=__von=-10000000__viertel=__ds=2067 (accessed 01 08 2012)

LANGTHALER E, SINABELL F. Abschied von der 'Agricultur'?. Agrarkulturen in Niederösterreich 1850-2000. In: Niederösterreich und seine Kulturen. (Wagner M,ed), Böhlau Verlag Wien, Vienna, 2007.

LBG (LBG Österreich GmbH): Buchführungsergebnisse 2010 der Land- und Forstwirtschaft Österreichs. LBG, Vienna, 2011

LEBEL L, ANDERIES JM, CAMPBELL B, FOLKE C, HATFIELD-DODDS S et al. Governance and the capacity to manage resilience in regional social-ecological systems. Ecology and society 2006,11 (1): 19. [online] URL: http://www.ecologyandsociety.org/vol11/iss1/art19/ (accessed 07 07 2012)

LEITZMANN C, Formen der Ernährungstherapie. Vollwerternährung – eine naturheilkundliche Ernährungsweise. In: Ernährung und Fasten als Therapie (STANGE R, LEITZMANN C, ed), Springer Verlag, Berlin, Germany, 2010; 107-121

LOWER AUSTRIAN PROVINCIAL GOVERNMENT, department for food controls: written electronic message to number of organic farms in Lower Austria, 2011

MANKIV GN: Makroökonomik. Gabler Verlag, Wiesbaden, Germany, 1996

MARSDEN T: Towards a real sustainable agri-food security and food policy: beyond the ecological fallacies? The Political Quarterly 2012; 83: 139-145

MASTEN AS, GEWIRTZ AH. Resilience in development. The importance of early childhood. In: Encyclopedia on Early childhood development (TREMBLAY AE, BARR RG, PETERS RDeV, ed). Centre of Excellence for Early Childhood Development, Quebec, Montreal, 2006,1-6. online [URL]: http://www.child-encyclopedia.com/Pages/PDF/Masten-GewirtzANGxp.pdf (accessed: 25.07.2012)

MÜLLER W: Agroklimatische Kennzeichnung des Marchfelds. Beiheft 3. In: Jahrbuch der Zentralanstalt für Meteorologie und Geodynamik, ZAMG, Wien, 1993

NELSON GC. Chapter 3. Drivers of ecosystem change: summary chapter. In: Ecosystems and human well-being: Current state and trends. Findings of the condition and trends working group of the Millennium Ecosystem Assessment (HASSAN R, SCHOLES R., ASH N, ed). Island Press, Washington/Covelo/London, 2005, 74. online [URL]: http://www.maweb.org/documents/document.765.aspx.pdf (accessed 05.05.2012)

NESTROY O. Landschaftsökologische Untersuchungen im Gebiete des Marchfeldes, Österr. Agrarverlag, Vienna, 1973

NEUDORFER W. Tendencies in field irrigation as shown in the example of the region Marchfeld in Austria. In: Soil physics and rural water management – progress, needs and challenges. Proceedings of the International Symposium SOPHYWA, University of Natural Resources and Applied Life Sciences, Vienna, 2006, 117-120

OCHSENHERZ. Ochsenherz Gärtnerhof. Über uns. Ochsenherz, 2012. online [URL]: http://www.ochsenherz.at/gaertnerhof.html (accessed 07 09 2012)

PAULESICH R, FRIESENBICHLER R, BOLEY T: EASEY. Ecological And Social EfficiencY. Eine Anwendung als Subindex an der Wiener Börse. Berichte aus Energie- und Umweltforschung 63/2006, Federal Ministry of Transport, Innovation and Technology, Vienna, 2006a

PAULESICH R: EASEY methodology. Unpublished information to the extended EASEY model (personal information), 2007a

PAULESICH R, BOHLÄNDER K, HASLBERGER AG. Integration of resilience into sustainability model for analysis of adaptive capacities of regions to climate change: the EASEY model. In: Sustainable food production and ethics. Preprints of the 7th Congress of the European Society for Agricultural and Food Ethics EurSAFE 2007 (ZOLLITSCH W, WINKLER C, WAIBLINGER S,HASLBERGER AG, ed). Wageningen Academic Publishers, Vienna, 2007b; 145-150

PAULESICH R, BOLEY T, AICHINGER A, FRIESENBICHLER R; KÖSSLER W et al. Implementierung eines Nachhaltigkeitsindex an der Wiener Börse. Berichte aus Energie und Umweltforschung 16/2006, Federal Ministry of Transport, Innovation and Technology, Vienna, 2006b

PAULESICH R, BURGHART H, BOHLÄNDER K, HASLBERGER AG. Assessment of Resilience of agro-ecological and social System in Vienna Region in Response to Climate Change using an Integrated Model. Discussion Paper for the Open Science Conference of the Earth System Science Partnership, Bejing, China, 09.11. – 12.11. 2006, 2006c

PICHLER D. Hochwasserschutz in NÖ am Beispiel der Donau. In: Berichte der Geologischen Bundesanstalt, Band 88 (Geologische Bundesanstalt, ed), Geologische Bundesanstalt, Vienna, 2011, 37-43

PRETTY J. Some benefits and drawbacks of local food systems. A briefing note for Sustain's Agri-food network, 2001. Online [URL]: www.sustainweb.org/pdf/afn_m1_p2.pdf (accessed 15 05 2012)

PRETTY J. The living land: Agriculture, food and community regeneration in rural Europe. Earthscan, London, 1998

REGION MARCHFELD: Grundwasserhilfe Marchfeld. Eine Initiative der Region Marchfeld in Zusammenarbeit mit dem Land Niederösterreich, dem BMLFUW und der Betriebsgesellschaft Marchfeldkanal. Region Marchfeld, 2011. Online [URL]: http://www.deutsch-wagram.gv.at/gemeindeamt/download/Infoseite_Grundwasserhilfe_MAREV.pdf (accessed 080 8 2012)

RENTING H, MARSDEN TK, BANKS J. Understanding alternative food networks: Exploring the role of short food supply chains in rural development. Environment and planning A 2003, 35: 393 – 411

RESILIENCE ALLIANCE. Assessing resilience in social-ecological systems: Workbook for practitioners. Revised version 2.0. Resilience Alliance, 2010. online [URL]: http://www.resalliance.org/srv/file.php/261 (accessed 06 06 2012)

RISCHBECK P: Der Einfluss von Klimaänderung, Bodenbearbeitung und Saattermin auf den Wasserhaushalt und das Ertragspotential von Getreide im Marchfeld. Thesis, BOKU, Vienna, 2007

RÖTZER H: Die Entwicklung der pannonischen Steppenlandschaft und der sie bestimmenden gesellschaftlichen Werthaltungen am Beispiel des österreichischen Marchfelds. BOKU, Thesis, Vienna, 2004

SCHILDER O: Der politische Bezirk Gänserndorf in Wort und Bild. Ein Heimatbuch für Schule und Haus. Gänserndorf, Gänserndorf Austria, 1970

SCHMIDHUBER J, TUBIELLO FN. Global food security under climate change. Proceedings of the National Academy of Sciences of the United States of America 2007,104(50):19703–19708

SCIALABBA NEH, MUELLER-LINDENLAUF M. Organic agriculture and climate change. Renewable Agriculture and Food Systems 2010; 25: 158-169

SHERRIEB K, NORRIS FH, GALEA S. Measuring capacities for community resilience. Soc Ind Res 2010; 99: 227-247.

SIMMIE J, MARTIN R. The economic resilience of regions: towards an evolutionary approach. Cambridge J Regions Econ Soc 2010, 3: 27-43. [online] URL:http://cjres.oxfordjournals.org/content/3/1/27.full.pdf+html (accessed 07 07 2012)

SINGH RJ, TURNER NJ, PANDEY CB:"Tinni" rice (oryza rufipogon Griff.) production: an integrated sociocultural agroecosystem in Eastern Uttar Pradesh of India. Environmental Management 2012, 49: 26-43.

SOLOMON S, QIN D, MANNING M, MARQUIS M, AVERYT K et al. Climate Change 2007. The Physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom, 2007

SOUSSANA JF, GRAUX AI, TUBIELLO FN. Improving the use of modelling for projections of climate change impacts on crops and pastures. Journal of experimental botany 2010, 61 (8): 2217-2228.

STATISTICS AUSTRIA. Agrarstrukturerhebung 2010. Betriebsstruktur. Schnellbericht. Statistics Austria, Vienna, 2012a

STATISTICS AUSTRIA. Landwirtschaftliche Haupt- und Kleinproduktionsgebiete Österreichs, Gebietsstand 2010. Statistics Austria, 2012b. [online] URL: http://www.statistik.at/web_de/static/landwirtschaftliche_haupt-_und_kleinproduktionsgebiete_oesterreichs_gebiet_027513.pdf (accessed 24 08 2012)

STATISTICS AUSTRIA, 2012c: Haupt und Kleinproduktionsgebiete mit Gemeinden, Gebietsstand 2012, 2012c. [online] URL: http://www.statistik.at/web_de/static/zuordnung_der_gemeinden_zu_den_haupt-_und_kleinproduktionsgebieten_gebiets_027223.pdf (accessed 29 08 2012)

STATISTICS AUSTRIA . Agrarstrukturerhebung 2010 – Bodennutzung, STATcube; statistical data base of STATISTICS AUSTRIA, 2012d. [online] URL: http://sdb.statistik.at/superwebguest/login.do?guest=guest&db=deas1001 (accessed 15 09 2012)

STATISTICS AUSTRIA. AS 2010 – Struktur der Betriebe. Haupterwerbsbetriebe. Statistics Austria, 2012e. [online] URL: http://www.statistik.at/web_de/statistiken/land_und_forstwirtschaft/agrarstruktur_flaechen_ertraege/betriebsstruktur/index.html (accessed 05 09 2012)

STATISTICS AUSTRIA: AS 2010 – Struktur der Betriebe. Fremdenverkehr in landwirtschaftlichen Betrieben. Statistics Austria, 2012f. [online] URL: http://www.statistik.at/web_de/statistiken/land_und_forstwirtschaft/agrarstruktur_flaechen_ertraege/betriebsstruktur/index.html (accessed 05 09 2012)

STATISTICS AUSTRIA: Land-und Forstwirtschaftliche Erzeugerpreise 2012, Statistics Austria,2012g. [online] URL: http://www.statistik.at/web_de/static/land-_und_forstwirtschaftliche_erzeugerpreise_2012_063080.xlsx (accessed 05 09 2012)

SUNDSTROM SM, ALLEN CR, BARICHIEVY AC. Species, functional groups, and thresholds in ecological resilience. Conservation biology 2012; 26 (2): 305-314

THALER S, EITZINGER J, DUBROVSKY M, TRNKA M. Climate change impacts on selected crops in Marchfeld, Eastern Austria. In: American Meteorological Society, 28th conference on agricultural and forest meteorology, Orlando, Florida, 2008, Paper 10.7

UNEP(United Nations Environment Programme). Global environmental outlook 5. Environment for the future we want. Malta: Progress Press Ltd, 2012

UNFCCC (United Nations Framework Convention on Climate Change). Background on the UNFCCC: The international response to climate change. [online] URL: http://unfccc.int/essential_background/items/6031.php (accessed 05 09 2012)

WALKER B, GUNDERSON L, KINZIG A, FOLKE C, CARPENTER S et al. A handful of heuristics and some propositions for understanding resilience in social-ecological systems. Ecology and society 2006, 11 (1): 13. [online] URL: http://www.ecologyandsociety.org/vol11/iss1/art13/ (accessed: 07.06.2012)

WELLS MP, GROSSMANN D, NAVAJAS H. Terminal evaluation of the UNEP/GEF Project “Millennium Ecosystem Assessment”, UNEP, 2006. online [URL]: http://www.unep.org/eou/Portals/52/Reports/Millennium%20Eco%20Assessment%20Report%20unedited.pdf (accessed 05.05.2012)

WIEN ENERGIE: Windpark Glinzendorf und Ebreichsdorf, 2012. online [URL]: http://www.wienenergie.at/eportal/ep/channelView.do/pageTypeId/11893/channelId/-43816 (accessed 08 08 2012)

WILKINS JL: Eating right here: moving from consumer to food citizen. Agriculture and Human Values 2005; 22: 269-273

WKO (Wirtschaftskammer Österreich). Tourismus und Freizeitwirtschaft. Arbeitsgemeinschaft Wirtschaft und Schule, Vienna, 2008. online [URL]: http://www.bmwfj.gv.at/Tourismus/TourismusstudienUndPublikationen/Documents/mp_tourismus_und_freizeitwirtschaft[1].pdf (accessed 08 08 2012)

WOOD S, EHUI S, ALDER J, BENIN S, CASSMAN KG et al. Chapter 8. Food. In: Ecosystems and human well-being: Current state and trends. Findings of the condition and trends working group of the Millennium Ecosystem Assessment (HASSAN R, SCHOLES R., ASH N, ed). Island Press, Washington/Covelo/London, 2005, 209-241. online [URL]: http://www.maweb.org/documents/document.277.aspx.pdf (accessed 05.05.2012)

ZAMG (Zentralanstalt für Meteorologie und Geodynamik): Klimadaten von Österreich 1971-2000. Station Groß-Enzersdorf. ZAMG, 2012. online [URL]: http://www.zamg.ac.at/fix/klima/oe71-00/klima2000/klimadaten_oesterreich_1971_frame1.htm (accessed: 10 08 2012)

8 Annex

8.1 Evaluation criteria for resilience assessments

Table 8. Recommendations for food consumption according to the concept of the whole-food diet (for healthy adults) with regard to cereals, vegetables and sugar intake:

Source: LEITZMANN, 2010, 115-117 (translated from German)

Value of food consumption	1 - Highly recommended	2 - Recommended	3 - Less recommended	4 - Not recommended
Amount of processing	Minimally processed, unheated food	Moderate processed, heated food	Highly processed, conserved food,	Excessive processed, isolated food, preparations
Recommended quantities	About half of daily food intake	About half of daily food intake	Seldom consumed	Avoid consumption
Vegetables/fruits	Fresh vegetables*	Heated vegetables	Canned vegetables	Food supplements
	Lacto-fermented vegetables	Heated fruits	Canned fruits	Frozen prepared dishes
	Fresh fruits	Frozen vegetables		
		Frozen fruits		
Cereals	Sprouted grain	Whole-meal products	Not whole-meal products	Cereal-based starch
	Whole grain cereals	Whole grain foods	Husked rice	
	Fresh rolled cereal grains			
Sweeteners	Sweet and fresh fruits	Unheated, diluted honey	Heated honey	Sweets and sweet goods
		Dried, not sulphurated fruits, soaked in water	Dried, sulphurated fruits	Isolated sugar
			Thick juices	Artificial sugar
			Syrup	Low-calorie, artificial sweeteners
			Unrefined cane sugar, unrefined beet sugar	

Table 9. Behavior-based indicators for assessing agro-ecological systems, part I

Source: CABELL and OLEOFSE, 2012

Table 1. Indicators for assessing agroecosystem resilience.

Indicator (sources)	Definition	Implications	What to look for
Socially self-organized (Levin 1999, Holling 2001, Milestad and Darnhofer 2003, Atwell et al. 2010, McKey et al. 2010)	The social components of the agroecosystem are able to form their own configuration based on their needs and desires	Systems that exhibit greater level of self-organization need fewer feedbacks introduced by managers and have greater intrinsic adaptive capacity	Farmers and consumers are able to organize into grassroots networks and institutions such as co-ops, farmer's markets, community sustainability associations, community gardens, and advisory networks
Ecologically self-regulated (Sundkvist et al. 2005, Ewell 1999, Jackson 2002, Swift et al. 2004, Jacke and Toensmeier 2005, Glover et al. 2010, McKey et al. 2010)	Ecological components self-regulate via stabilizing feedback mechanisms that send information back to the controlling elements	A greater degree of ecological self-regulation can reduce the amount of external inputs required to maintain a system, such as nutrients, water, and energy	Farms maintain plant cover and incorporate more perennials, provide habitat for predators and parasitoids, use ecosystem engineers, and align production with local ecological parameters
Appropriately connected (Axelrod and Cohen 1999, Holling 2001, Gunderson and Holling 2002, Picasso et al. 2011)	Connectedness describes the quantity and quality of relationships between system elements	High and weak connectedness imparts diversity and flexibility to the system; low and strong impart dependency and rigidity	Collaborating with multiple suppliers, outlets, and fellow farmers; crops planted in polycultures that encourage symbiosis and mutualism
Functional and response diversity (Altieri 1999, Ewell 1999, Berkes et al. 2003, Luck et al. 2003, Swift et al. 2004, Folke 2006, Jackson et al. 2007, Di Falco and Chavas 2008, Moonen and Barbieri 2008, Chapin et al. 2009, Darnhofer et al. 2010*b*, McIntyre 2009)	Functional diversity is the variety of ecosystem services that components provide to the system; response diversity is the range of responses of these components to environmental change	Diversity buffers against perturbations (insurance) and provides seeds of renewal following disturbance	Heterogeneity of features within the landscape and on the farm; diversity of inputs, outputs, income sources, markets, pest controls, etc.
Optimally redundant (Low et al. 2003, Sundkvist et al. 2005, Darnhofer et al. 2010*b*, Walker et al. 2010)	Critical components and relationships within the system are duplicated in case of failure	Also called response diversity; redundancy may decrease a system's efficiency, but it gives the system multiple back-ups, increases buffering capacity, and provides seeds of renewal following disturbance	Planting multiple varieties of crops rather than one, keeping equipment for various crops, getting nutrients from multiple sources, capturing water from multiple sources
Spatial and temporal heterogeneity (Alcorn and Toledo 1998, Devictor and Jiguet 2007, Di Falco and Chavas 2008)	Patchiness across the landscape and changes through time	Like diversity, spatial heterogeneity provides seeds of renewal following disturbance; through time, it allows patches to recover and restore nutrients	Patchiness on the farm and across the landscape, mosaic pattern of managed and unmanaged land, diverse cultivation practices, crop rotations
Exposed to disturbance (Gunderson and Holling 2002, Berkes et al. 2003, Folke 2006)	The system is exposed to discrete, low-level events that cause disruptions without pushing the system beyond a critical threshold	Such frequent, small-scale disturbances can increase system resilience and adaptability in the long term by promoting natural selection and novel configurations during the phase of renewal; described as "creative destruction"	Pest management that allows a certain controlled amount of invasion followed by selection of plants that fared well and exhibit signs of resistance
Coupled with local natural capital (Ewell 1999, Milestad and Darnhofer 2003, Robertson and Swinton 2005, Naylor 2009, Darnhofer et al. 2010*a*,*b*, van Apeldoorn et al. 2011)	The system functions as much as possible within the means of the bioregionally available natural resource base and ecosystem services	Responsible use of local resources encourages a system to live within its means; this creates an agroecosystem that recycles waste, relies on healthy soil, and conserves water	Builds (does not deplete) soil organic matter, recharges water, little need to import nutrients or export waste

Table 10. Behavior-based indicators for assessing agro-ecological systems, part II

Source: CABELL and OLEOFSE, 2012

Reflective and shared learning (Berkes et al. 2003, Darnhofer et al. 2010*b*, Milestad et al. 2010, Shava et al. 2010)	Individuals and institutions learn from past experiences and present experimentation to anticipate change and create desirable futures	The more people and institutions can learn from the past and from each other, and share that knowledge, the more capable the system is of adaptation and transformation, in other words, more resilient	Extension and advisory services for farmers; collaboration between universities, research centers, and farmers; cooperation and knowledge sharing between farmers; record keeping; baseline knowledge about the state of the agroecosystem
Globally autonomous and locally interdependent (Milestad and Darnhofer 2003, Walker et al. 2010, van Apeldoorn et al. 2011)	The system has relative autonomy from exogenous (global) control and influences and exhibits a high level of cooperation between individuals and institutions at the more local level	A system cannot be entirely autonomous but it can strive to be less vulnerable to forces that are outside its control; local interdependence can facilitate this by encouraging collaboration and cooperation rather than competition	Less reliance on commodity markets and reduced external inputs; more sales to local markets, reliance on local resources; existence of farmer co-ops, close relationships between producer and consumer, and shared resources such as equipment
Honors legacy (Gunderson and Holling 2002, Cumming et al. 2005, Shava et al. 2010, van Apeldoorn et al. 2011)	The current configuration and future trajectories of systems are influenced and informed by past conditions and experiences	Also known as path dependency, this relates to the biological and cultural memory embodied in a system and its components	Maintenance of heirloom seeds and engagement of elders, incorporation of traditional cultivation techniques with modern knowledge
Builds human capital (Buchmann 2009, Shava et al. 2010, McManus et al. 2012)	The system takes advantage of and builds "resources that can be mobilized through social relationships and membership in social networks" (Nahapiet and Ghoshal 1998:243)	Human capital includes: constructed (economic activity, technology, infrastructure), cultural (individual skills and abilities), social (social organizations, norms, formal and informal networks)	Investment in infrastructure and institutions for the education of children and adults, support for social events in farming communities, programs for preservation of local knowledge
Reasonably profitable	The segments of society involved in agriculture are able to make a livelihood from the work they do without relying too heavily on subsidies or secondary employment	Being reasonably profitable allows participants in the system to invest in the future; this adds buffering capacity, flexibility, and builds wealth that can be tapped into following release	Farmers and farm workers earn a livable wage; agriculture sector does not rely on distortionary subsidies

Table 11. Characteristics of farm resilience.
Source: DARNHOFER and MILESTAD, 2003 (translated from Germany)

Characteristics of farm resilience	Relevant aspects of IFOAM basic guidelines	Tendencies, which weakens farm resilience
Buffer capacity		
Understanding cycles of natural, unpredictable events	• Work compatibly with natural cycles • Crafts and farming skills for use based on experience, site-specific knowledge • Pest control by natural predator management, habitat management	• Reliance on external expertise and standardized production methods • Specialization and pressure to raise productivity negatively affect diversity and replace environmental concerns
Diversity and flexibility	• Variety of plant and livestock production shall enhance interrelationship of single elements • Creation of a harmonious balance between plant and livestock production	• Increased specialization and reduction in the number of mixed farms • Product definition and standardization undermine farmers´ choice to select crop cultivars and seeds
Responsibility	• Establishing a harmonious relationship between mineral resources, plants and livestock • Take into account physiological and ethological needs of livestock • Socially just and environmentally responsible food value chain	• Without considering externalities, economic pressure leads to short-term profits
Capacity to self-organize		
Independency from information given by external institutions	• Recognize local knowledge and traditional land-use management • Crop production and cultivars are suited to local conditions • No use of genetic modified seeds, pollen or transgenic plants	• Dependency from central management and institutionalized lobbies • Dominance of supermarkets threatens regional coherence and dynamics
Local marketing networks	• supporting local and regional production and distribution	• Contract growing for agro-food-industry
Independency from external inputs	• Return appropriate amounts of organic matter to the soil • Careful management based on skill, experience and knowledge can avoid use of purchased inputs • Total feed should be produced at the farm or at least in the region	• Specialization and mass production need standardized production methods and purchased inputs • Often long transport to centralized enterprises to gain inputs • Guidelines require just a specific amount of feed produced at the farm itself
Ability to learn and to adapt		
Learning processes	• Pest control shall be conducted by knowledge and interruption of environmental needs • Farmers shall take action in retain and improve landscape and biodiversity	• Reliance on technical recommendations resulted from experiments under controlled conditions • Focus on minimum standards to fulfill guidelines
Feedback mechanism	• Farmers should arrange system elements to use water resources responsibly and according to local climate and geography	• Focus on market signals • Negative effects on the environment will be ignored, because it is not honored by the market

8.2 Conference papers

This thesis was part of the interdisciplinary research project “Climate Change and Regional Sustainability”. The following papers resulted from this project:

- Paulesich R., Bohländer K., Haslberger A.G. Integration of resilience into sustainability model for analysis of adaptive capacities of regions to climate change. The EASEY model. 7th Congress of the European Society for Agricultural and Food Ethics. EurSafe 2007, September 13-15, 2007, Vienna, Austria (PAULESICH et al, 2007b)

- Paulesich R., Burghart D., Bohländer K., Haslberger A.G. Assessment of Resilience of agro-ecological and social System in Vienna Region in Response to Climate Change using an Integrated Model. presented at the Earth System Science Partnership. Open Science Conference 2006, November 09-12, 2006, Bejing, China (PAULESICH et al, 2006c)

These papers are presented on the following pages.

Integration of resilience into sustainability model for analysis of adaptive capacities of regions to climate change. The EASEY model

R.Paulesich[1], K. Bohländer[2], A.G. Haslberger[3],

1 - University of Economics and Business Administration, Institute for Regional- and Environmental Economics and Management, Nordbergstrasse 15, A - 1090; 2 & 3 - Dep. for Nutritional Sciences, Center for Ecology, Univ. of Vienna, Althanstrasse 14, A-1090 Vienna

Abstract:

Global and regional management and governance will need to establish integrative models considering agro-ecological, social and economic factors to increase resilience of food production.

The paper discusses an integrated concept for the analysis of adaptive capacities of regions to climate change. Data generation and analyses is carried out along three dimensions:

(1) The agricultural production process has to be defined whether the cultivation only or further food processing in a sense of supply chain should be scrutinised;

(2) Regional stakeholders of the production process have to be identified. Six categories are usually alleged: process holders, ecology, society, customers, market and finance;

These two dimensions are representing the state of the art in evaluating projects or programs. Here quantitative and qualitative data are used. By involving stakeholders (face to face interviews, workshops) some regional specific indicators will come up.

(3) The third dimension makes the difference. It expresses three sustainability goals pre-structured by principles of multilateral organisations and European Union strategic policy intentions which can be seen as a democratically legitimated basis for a trans-disciplinary dialogue and a discourse between science and society.

This methodology can be applied as a self assessment and a benchmarking tool as well. The combination with a participative generated regional development concept could establish a feedback loop to enhance dialog between science and society. Resilience means then the availability of societal options for a flexible response to climate change effects.

Key Words: evaluation concept of regional ability to respond external shocks

Framing

Sustainability as it is most cited and once written in Brundtland-Report (1987) is defined as development, meeting the needs of the present generation without compromising the ability of future generations to meet their needs. Implementing this so to say definition, the United Nations Conference (1992) on Environment and Development in Rio de Janeiro drew up a rough structured political concept – the 3 columns of sustainable Development, challenging policy makers to weight interests of economy, society and environment equally. On that score, in Lissabon (2000) and Göteborg (2002) as well the Council of the European Union paved the way by declaring two strategies: Enhancement of Competitiveness and sustainable Development. Now the question arises how to operationalise such a political claim?

Operationalising

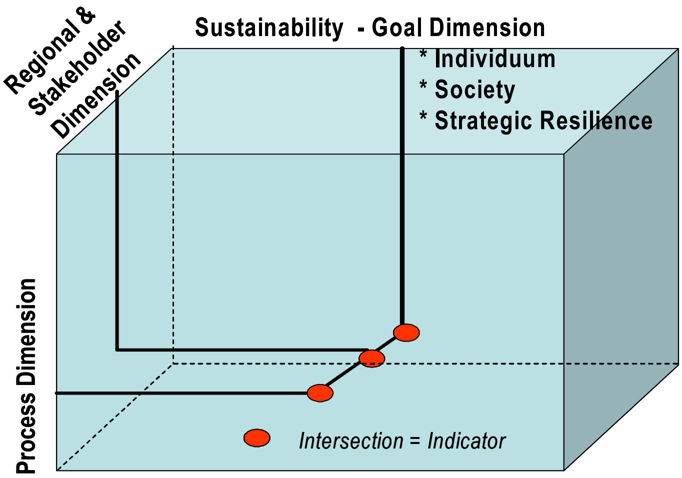
EASEY is the four letter word for ecological and social efficiency. The term efficiency shall provoke a debate on effectiveness and sufficiency when the model is going to be introduced. The intention is to enhance self reflection the understanding of the normative character of sustainability and development.

Concepts recently try to operationalise developing or / and assessing sustainability are to categorise as;

1. Frameworks for communities and regions (www.iisd/pdf/bellagio.pdf or manuals for LA21-projects);
2. Frameworks for business and companies (Global Reporting Initiative www.globaloreporting.org or ISO 14000 series).

Concepts in both categories lack of either comparability of results (1) or usability for all stakeholders (2). The aim is therefore to link micro-, meso- and macro level first in concept than in pilot practice to derive experience and than arguments for better understanding and decision making on each level.

Model of Sustainable Development and Evaluation



This model differs to conventionally used ones. The first two dimensions - (1) processes and (2) regional stakeholders - are representing the state of the art in evaluating projects or programs as well as corporate sustainability performance. The question arises whether they cover all requirements emerging from sustainability. And further more when sustainability is a normative societal issue these requirements underlie continuous changes. Which requirements a model have to comply?

- First: legal compliance is not enough as well as positive market response to a brand name or product or in political terms a qualitative democratic majority.
- Second: intergenerational justice - we have to go beyond the time horizon of a single generation at least.

We try to respond by introducing a third dimension, which expresses sustainability goals. These should be the result of an interscience and / or science and society discourse. Thus is pre-structuring the evaluation track from natural sciences [hard facts] to regional aspects and includes the normativity of preferences about social choice [soft facts].

Process Dimension

We have to face up to a first decisive question here. Shall we define the food production as a part of the ecological or the socio technological system? In the first case food production is a part of ecological functions and services with less societal sovereignty than in the second case.

Food production belongs to more than one subsystem (economy, society) but is mainly part of superior system nature. Therewith food production differs clearly from subsystem economy, which is more strongly embedded in "society" than in "nature"- in terms of its messages. To come to the point, in their decisions and actions, food production stakeholders are not able to apply their specific system logics for other subsystems.

The process dimension of the model addresses efficiency and effectiveness in production of goods and services. Ecological efficiency of food production is measured by relation between applied material, energy, labour and extant amount in products. Effectiveness depends on need of repairs respectively applicability of products. In case of food production effectiveness is simply nutritional value or in other words contribution to health by diet. Effectiveness also reflects dynamic development of an organisation. In case of food production, vegetable farmers are driven by market opportunities mediated by frozen food producer Frenzel Austria Frost in Groß Enzersdorf. It provides information about strategic investments to current achieved fruits ratio, not only in terms of fiscal and income levels.

Stakeholder Dimension

The EASYE model is based on the observance that companies are always affected by stakeholders even by those assigned to the non market environment. In case of food production, especially agriculture, wide political and societal interests exist often conflictive for example relative price (bearable share of household income) and quality in ecological and physiological terms. NGOs on several levels denounce offences against ecological and health standards. All these is determining informal and formal market conditions.

In terms of agriculture as a link in the supply chain of food production family is the most important stakeholder and members of staff are narrowed to seasonal workers. Clients are on the one hand final consumers due to direct selling and on the other hand pose a strategic alliance with food industry. In order to evaluate this strategic alliance special methodology used in the management of supply chain is necessary.

Social responsibility is another critical topic, due to the kind of industrial production influencing family and local society, as quality of products with consequences for consumer´s health. In both cases choice is limited due to laws and board of control but wide range makes visible difference in impact on environment and society. Illustrative example is comparing tendency to reduce the value of diet with life-supporting expenditures in general or time exposure in relation to spare time or career (work life balance).

Goal Dimension

The claim is that, in comparison with other concepts applied at the moment, this concept reflects term definitions of sustainable development more comprehensively. The present concepts mirror and assess according to benchmarks or threshold values, respectively. This leads to a merely peripheral consideration of indicators of social responsibility, at the minimal level often prescribed by law. Neither the sustainability definition proposed in the Brundtland Report nor the common 3-tier model offer starting points for an operationalisation that could do justice to the normative character and the socio-political target, respectively.

The solution for both questions lies in adding a goal dimension to the repertoire of instruments (indicator set e.g.). For this purpose, an existing three dimensioned system of goal for the conception of regional economic development is used.

Table: Overview of the three goal dimensions of sustainable development

Ensuring human existence					**Maintaining the social productivity potential**					**Maintaining the opportunities for development and action**				
health	Basic provision	Ensuring existence	Security of revenue and assets	Possibilities of making use of the environment	Use of renewable resources	Use of non-renewable resources	The environment as a rubbish-dump	Risks	Material, human and knowledge capital	Equality of chances	participation	Cultural heritage and cultural diversity	Safeguarding the cultural function of	Maintaining social resources

This goal system does not substitute individual goals of process participants (involved people). It points out opportunities provided by sustainable development and limits which it sets.

A system of individual process participant goals is ancillary to a system of sustainability goals, which represents multilateral agreements, international principles as well as political intentions of the European Union regarding sustainable development. In either case, agriculture, food production respectively – defined as a processing chain – is part of more than one category in the sustainability goal dimension.

The question of how this addition can be fruitfully employed for the assessment of the sustainability performance of a food production system will be answered by applying this model in a research project. The methodology includes instruments as surveys to get to know peoples preferences, priorities and assignments to who is responsible for achieving which goal (monitoring, keeping the direction etc.)

Resilience

The concept of resilience is widely used in ecology but its meaning and measurement are contested. While some refer to it as a new paradigm, others see it as more of an expression, complimenting use of other terms, such as vulnerability or risk. Resilience is often used in physical or ecological context, but most of the literature clarifies that the study of resilience evolved from the disciplines of psychology and psychiatry in the 1940s.

Resilience has been defined in many ways. According to C. S. Holling it is the buffer capacity or the ability of a system to absorb perturbations, or the magnitude of disturbance that can be absorbed before a system changes its structure by changing the variables and processes that control behaviour. By contrast other definitions of resilience emphasize the speed of recovery from a disturbance, highlighting the difference between resilience and resistance. Therefore, resilience can be seen as a desired outcome but also as a process leading to a desired outcome.

Social resilience is defined as the ability of communities to withstand external shocks to their infrastructure. Deficient information, communications and knowledge among social actors, the lack of institutional and community organisation, weakness in emergency preparedness, political instability and the absence of economic health in a geographic area are factors in generating greater risk. Therefore, the concept of resilience, especially social resilience is growing on importance. The direct dependence of communities on ecosystem is an influence on their social resilience and ability to cope with shocks, particularly in the context of food security and coping with hazards.

Conceptualizing and measuring economic resilience shall be illustrated by the view to economic vulnerability on a macro level. The vulnerability and the resilience characteristics can be described by four scenarios (best worst case, subsistence and prodigal). The economic vulnerability index is based on criteria as economic openness, export share and dependence on strategic imports. All vulnerability indices lead to the conclusion that small states tends to be more economically vulnerable than larger ones.

The main meaning of economic resilience is the ability to recover from the negative impacts of external shocks. The three characteristics are therefore to recover more or less quickly from a shock by appropriate counteraction, to withstand the effects by absorption and last not least the ability of avoidance.

Components of the resilience index are shock-absorbing and shock-counteracting information about macroeconomic stability, which relates to aggregated demand and aggregated supply. The macroeconomic stability aspect is based on three variables namely the fiscal deficit to GDP ratio, the unemployment and inflation rate and the external debt to GDP ratio.

Shock-absorbing and shock-counteracting from a national point of view differs to an individual company's one. Nations operate within a frame of bi- and multilateral agreements (setting a stabile democratic political system as internally given), companies has to refer to national and international business regulations. Microeconomic efficiency is a further aspect of gaining resilience.

Next Steps

The Millennium Ecosystem Assessment provides a scheme which is to be classified between the two categories of sustainability concepts mentioned at the beginning. This intermediate position is characterised by

- Referring to Processes – direct and indirect drivers of change; strongly based by natural sciences; macro level view dominates;
- Goals to achieve – presenting human well being as strongly dependent from ecosystem services; not covering all societal needs regarding sustainable development.

It answers the question, why we should take action, but not sufficiently, who should take it and what is to do and which priorities we should care for. Comparability of results is achievable but usability for all stakeholders can not be taken for sure. Further research is needed to merge the EASEY model and the MA concept by carrying out a sub global assessment.

From a case study in Marchfeld, looking at the food production of the last 30 years (sugar beets, vegetables, maize, wheat), we conclude that there may be a number of opportunities to implement resilience strategies for a system like the food production area of Marchfeld.

In general, a portfolio approach based on managing a variety of risks and opportunities should be the most appropriate. The portfolio has to represent diversity on both levels nature (historical factors and recent recovery) and society (organisation of production, cultural heritage). The level of nature ranges from man made to intensive agriculture. The level of society extends from semi industrial farming to biological one and further more to management of protected reserves.

A portfolio approach is to be seen as a precautionary measurement because not only processes at these two levels should become robust and stabile, effects of losses are calculable, also the knowledge of society will rise by preparing for counteraction, absorption and avoidance. This knowledge provides additional economic, social, or environmental benefit.

References:

ALLENBY, B.; FINK, J. (2005); Toward Inherently Secure and Resilient Societies, Science, 309;1034 -1036

BRIGUGLIO, L.; et.al. (2004); Conceptualising and Measuring Economic Resilience. University of Malta, Department of Economics; www.um.edu.mt October 24th 2006 09:43

BRUCKNER, B.; PAULESICH, R. (Hg.) (2006); Nachhaltigkeit und Unternehmensfinanzierung. Beiträge zur aktuellen Diskussion und empirische Befunde; Hamburg Kovac

DARNHOFER, R. (2006); Resilienz und die Attraktivität des Biolandbaus für Landwirte; in: Bio Landbau in Österreich im internationalen Kontext. Band 2: Zwischen Professionalisierung und Konventionalisierung; GROIER, M.; SCHERMER, M. (Hg.) Wien

FISCHER, G.; SHAH, M.; VAN VELTHUIZEN, H. (2002); Climate Change and Agricultural Vulnerability. Institute for Applied Systems Analysis, Contribution to World Summit on Sustainable Development, Johannesburg

HARDI, P.; ZDAN, T. (1997); Assessing Sustainable Development. Principles in Practice; IISD Winnipeg CAN

KOPFMÜLLER, J.; et.al (2001); Sustainable Development from an Integrative Perspective Berlin p. 172

PAULESICH, R. (2006); EaseyX. Der HGF Ansatz in einem Modell zur Bewertung börsennotierter Unternehmen; in: Ein Konzept auf dem Prüfstand. Das integrative Nachhaltigkeitskonzept in der Forschungspraxis; Kopfmüller, J.; Berlin Sigma S 189 - 211

PAULESICH, R; et.al. (2006); Der Begriff "nachhaltige Entwicklung". Eine Einleitung und eine Annäherung an Begriffsverständnis und Schnittflächen; in: Nachhaltigkeit und Unternehmensfinanzierung. Beiträge zur aktuellen Diskussion und empirische Befunde; Hamburg Kovac S 1 bis S 29

Assessment of Resilience of agro-ecological and social System in Vienna Region in Response to Climate Change using an Integrated Model

Reinhard Paulesich[1] David Burghart[1] Katja Bohländer[2] Alexander Haslberger[2]

[1] Inst for the environment and regional development, Univ. for economics and business administration; [2]. Department for nutritional sciences and center for ecology, University of Vienna, Austria

Contact. Reinhard.paulesich@wu.wien.ac.at; Alexander.haslberger@univie.ac.at

Earth´s climate has changed during the past century and will continue to change significantly over the next few centuries. Findings from the international expert communities, summarized in the reports of the Intergovernmental Panel on Climate Change in 2001, illustrate, that changes will affect all parts of the climate system and will alter living conditions for plants, animals and human race.

Although ecosystems are dynamic and not static, their resilience – defined as the amount of change a system can undergo (and, therefore, the amount of stress it can sustain) and still retain the same controls on function and structure (still be in the same configuration—within the same domain of attraction) (Walker et al, 2002) – is limited for some properties. Therefore abrupt changes in climate will challenge existing ecosystems and in direct consequence every economic sector, but in a different way. (Kromp Kolb, 2004)

Historically, agricultural expansion has been the primary cause of ecosystem change. Overall, agricultural land use grew from around 265 million ha in 1700 to 1.2 billion ha in 1950 and now stands at over 1,5 billion ha. Annually, agricultural lands are expanded by about 0, 3%, an area comparable with the country of Greece. (Groom, 2006) Arable lands are almost fully exploited worldwide, with over 98% transformed, representing an almost complete loss of the communities and ecosystems that once occupied those areas. (Groom et al, 2006) Additionally to human activities, climate change and variability will result in irreparable damage to arable land, water, and biodiversity resources, with serious consequences for food production and food security, whereas most of these losses will occur in developing countries with low capacity to cope and adapt. (Shah, 2005)

According to IIASA the ability of agriculture to adapt to and cope with climate change will depend on such factors as population growth, poverty and hunger, arable-land and water resources, farming technology and access to inputs, crop varieties adapted to local conditions, access to knowledge, infrastructure, agricultural extension services, marketing and storage systems, rural financial markets, and economic status and wealth. (Fischer, 2002)

Climate Change will affect agriculture in many ways: Alteration of crop through growing needs of adaption, higher risks for extreme events, applicability of locations for specific products and changing pest infestation and pathogen. (Kromp-Kolb, 2004)

Food agriculture must be given highest political commitment and attention, because it is the dominant user of environment and natural resources, and it has the greatest impact on sustainability of ecosystems and their services. (Shah, 2005)

The complex interactions which need to be analyzed for an assessment of climate changes on resilience of ffod production systems including social resilience of global communities need dynamic integrated concepts such as provided by the Millennium ecosystem assessment.

All people depend on services supplied by ecosystems, either directly or in directly. However, many human and ecological systems are under multiple severe and mutually reinforcing stresses. Improvements in human well-being, enabled by economic growth, almost invariably lead to an increase in the per capita demand for provisioning ecosystem services such as food, fiber and water and in the consumption of energy and minerals and the production of waste.(http://www.millenniumassessment.org)

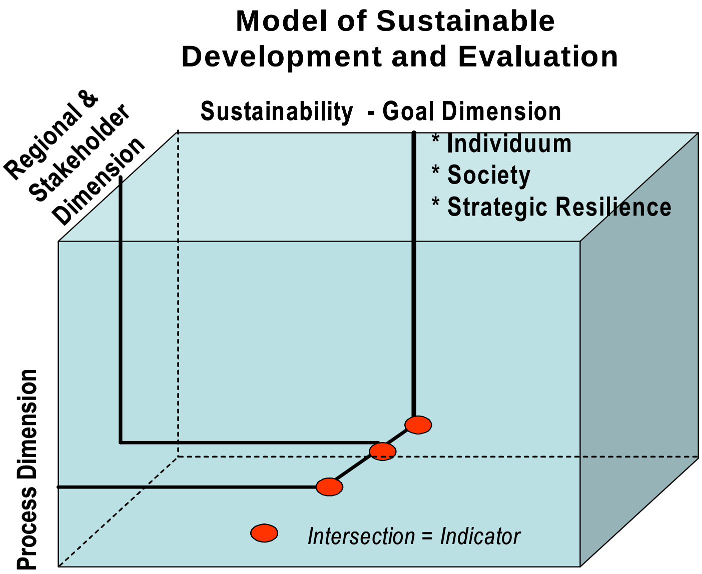
The Millennium Ecosystem focuses on how humans have altered ecosystems, and how changes in ecosystem services have affected human well-being, how ecosystem changes may affect people in future decades, and what types of responses can be adopted at local, national, or global scales to improve ecosystem management and thereby contribute to human well-being and poverty alleviation. (Ecosystems and Human Well-being: A Framework for Assessment, www.milleniumassessment.org)

Understanding the drivers, such as diverse drivers influencing climate change and factors enabling resilience , is essential to enhance positive and minimize negative impacts. Therefore it´s indispensable to find out the main natural or human-induced factors that directly or indirectly cause a change in an ecosystem. (Ecosystems and Human Well-being: A Framework for Assessment, www.milleniumassessment.org)
Soil and water are natural resources vital for mankind´s life. Sustainable management of these resources requires a comprehensive understanding of all physical, chemical and biological processes and their interactions occurring in the vadose zone. Soil erosion, drought, salinization, diffuse and point source contamination, floods, and climate change are major threats to the quantity as well as to the quality of these resources.

As an model for the assessment of sustainability the EASYmodel was selects because it enables the consideration of social objectives such as social resilience in addition to classical sustainability parameter such as processes and stakeholders.

The EASEY model is constructed to arrange available information and to explain complex correlations. Moreover, it admits classification and assessment of alternative choices for a better understanding of existing correlations. Nevertheless, the EASEY model provides the opportunity to evaluate the benefit of sustainability of enterprises.

Concept of EASEY X Evaluation is a three-dimensional approach of the whole food production. Starting from processes of enterprise, which have to be established for particular assessment, impact of activities made by enterprises to groups with demand is measured. Six of these processes are significant for the food production in Marchfeld: …



Case study Marchfeld

Marchfeld is one of the most important crop production regions in Austria (latitude 48°34´N, longitude 16°34´E and altitude 150m above sea level). It is situated in the east of Vienna as a part of the Vienna Basin and a junction region between the west European climate, which shows mild winter and humid, comparatively cool summer season and the continental influenced east European climate, which on the whole hold cold winters and dry, hot summers. (NESTROY, 1973) Its vegetation period is long and comes along with relative marginal precipitation and plenty of sunshine. Topographic and local climate conditions of this region lead to specialisation in agriculture towards cash crop production, whereas the predominant form of land use is agriculture with conventional or integrated production methods. (HADATSCH et al, 2000)
During the last 50 years intensive production breeds to constant rise of fertilisation, that is jointly responsible for current prevailing burden of groundwater with nitrate.
Further up to its geological and local climatic conditions, its growing fields and missing landscape elements such as hedges and wood, Marchfeld is exposed to eolian erosion. (VABITSCH, 2000).

The area selected for our case study, the Marchfeld has grounds, which are characterised as fruitful like black earth and grey earth on the one hand and on the other hand windborne sand and windborne soil, which could arise due to ripping turf for establishing acres, whereby humus layer below dry grassland could blow away again and secondary sand too, which makes cultivation more difficult. (HADATSCH, 2000)

However, organic farming, which is known to be more sustainable, is highly unrepresented in Marchfeld and has a stake in total farms of 1,5%, in contrast to 9% throughout Austria. (VABITSCH, A., 2000)

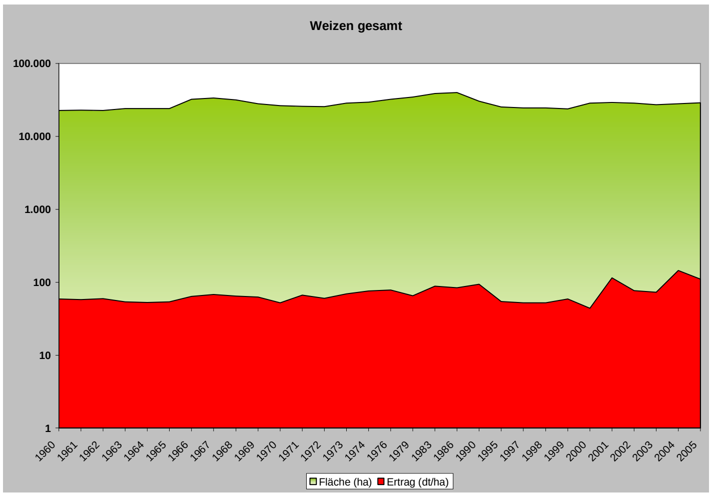
Marchfeld holds a total area of 95.000ha and 62.000ha acreage with basically fruitful soil **but with the addition of ir**rigation technology. (ÖSTAT, 1995)

Regarding to its dimension, acre is predominant. Structures are often linear due to natural rivers, but also because of the system of the Marchfeldkanal – a channel, which provides the region with water coming from the Danube.

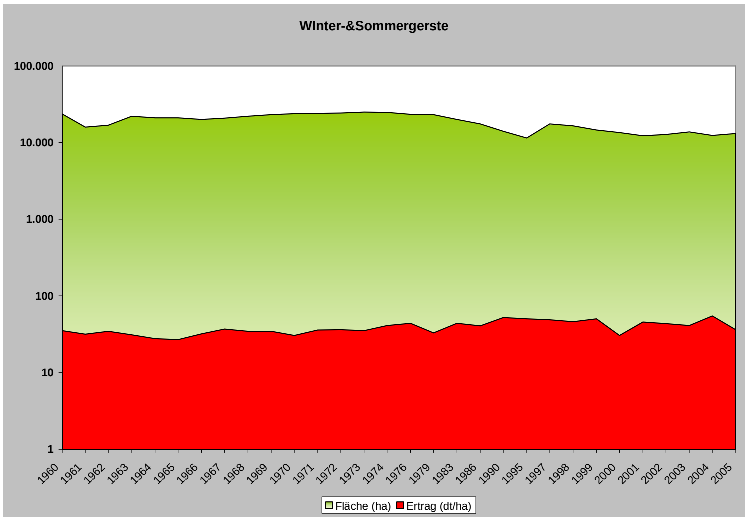
In 1995 2690 farms own about 86.700 ha area. In contrast to the rest of Austrians agricultural landscape Marchfeld is rich in farms with less than one hectare of cropland and farms of proportionally large size, latter because of crop production. Small agricultural cropland is five times as much represented and accounts for over 15% of total area. This significant difference is based on the high amount of permanent crop, which normally needs less space.
Vegetables take in about 5,9 % of total floor space and is therefore many times beyond national mean. Root crops like sugar beet and potatoes are also cultivated above average. (ÖSTAT 1997)

In these graphs you can see an overview of 4 products which are produced in the Marchfeld.

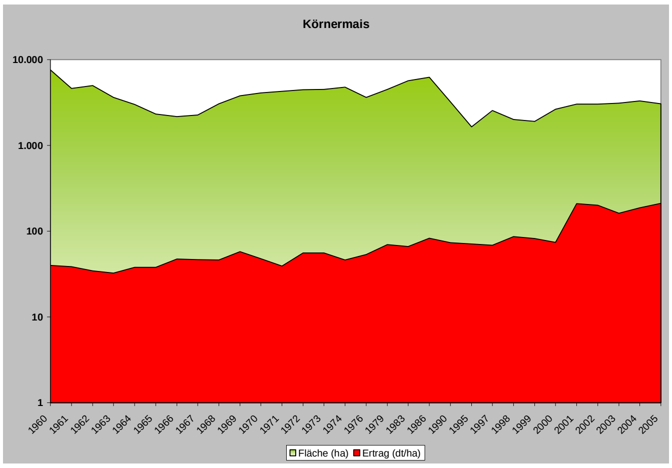
The first graph shows the wheat, which includes the winter and summer wheat and the soft and hard wheat. The expanse didn't really increase, only in 1990. There the expanse was doubled up, but the revenue didn't climb up.



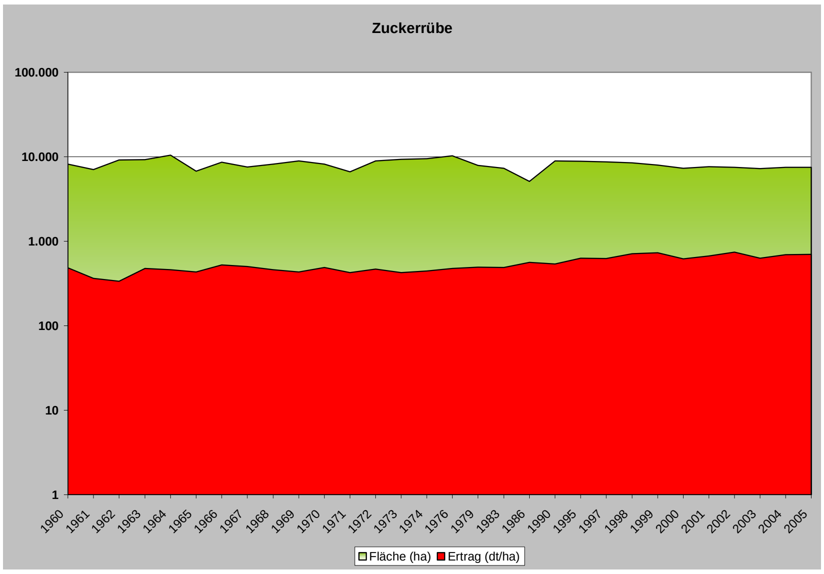
The next one shows the barley, which includes the winter and the summer barley. Form 1960 to 1980 the expanse was nearly the same, except one decline in1962, but after 1980 the expanse was reduced by the half. The revenue was always the same, only in 1990, 1999 and in 2004 it was doubled up.



This graph gives us an overview of the corn production. In 1960 and in 1986 the expanse nearly doubled than in the other years without an increase in the revenue. In the 2001 the revenue of corn increased from 72 to 210dt/ha, which cloud be depending on the new technologies.



The last graph shows the sugar beet. Except of some declines, the expanse was always the same, but there was a constant increase on the revenue.

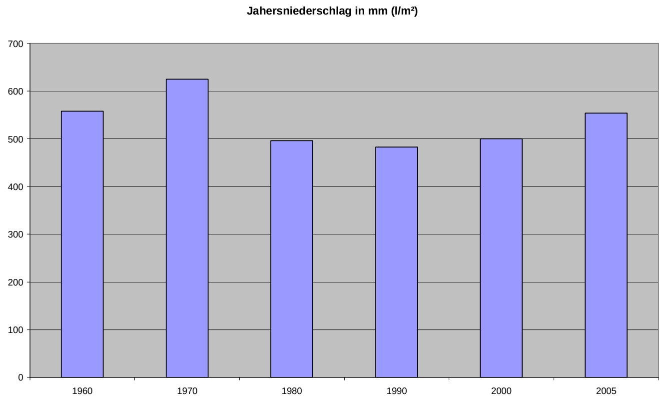


Since 1901 Marchfeld has a sugar refinery, which today belongs to AGRANA Beteiligungs-AG. About 1200 farmers from Marchfeld supply AGRANA with sugar beets. Sugar beets are known to need intensive care. In the past,sugar refineries used to pollute rivers with lots of organic material. Due to globalisation, open competition and growing environmental awareness, rethinking took place and leads to environmentally sound procedures.

High quality vegetables are in particular the basis for durable goods and frozen food. Field vegetable farming has a high productive capacity and has been intensified in the last decade. The most important field vegetables in the Marchfeld are onions, carrots, green peas, spinach and asparagus. Most of these have a low water tolerance and need – as well as the beet-growing area sufficient water supply. In the last two decades remarkable trends in farming and irrigation have taken place: grain irrigation has significantly decreased, on the other side irrigation of field vegetable has increased. Today especially field vegetables are very important for the income of the farmers. (KATZMAYER, 2003)

The main drivers for Marchfeld are overconsumption of soil and groundwater, and land-use.
In Marchfeld the annual precipitation averages around 530mm from 1978 to 2002, while potential evaporation averages around 760mm. This results in a negative water balance of monthly 40 – 60 mm from April till September. Thus, irrigation of vegetables and other premium crop is necessary to secure yields. Since 1936 the development of ground water balance shows a significant decline which comes along with solid rise of irrigation in the 1970s (BEHR et al, 1984) Ground water resources are overused which led to a tense situation for local population. To compensate for this partly home-made water shortage Marchfeldkanal-project was started in 1984 and realised in 2003. It is a multi purpose project, which should raise artificially ground water and provide irrigation. Nowadays water supply is secured by artificial recharge of groundwater and partially by using surface water instead of groundwater. (NEUDORFER, 2006)

This line graph shows the total precipitate in one year in the Marchfeld. The most precipitate was in the year 1970 with 625mm and after a fall in 1990 to 480mm, in 2005 the annual precipitate went up to 550mm.

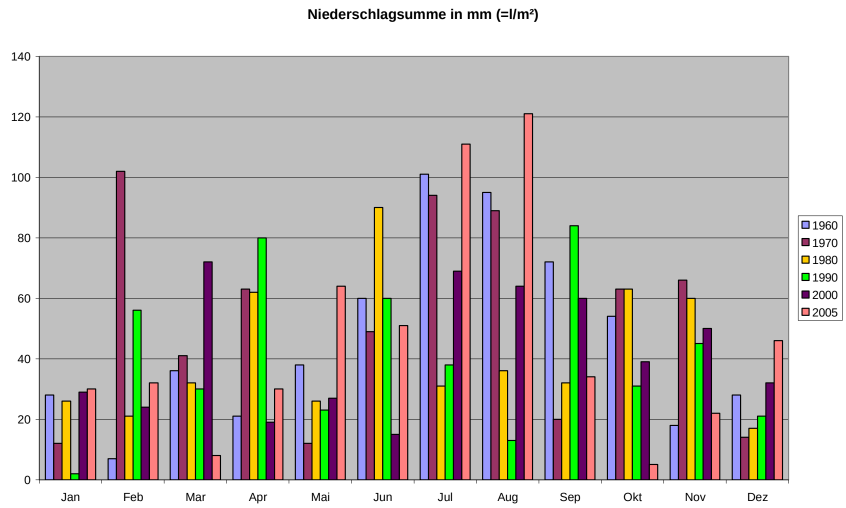


In the Marchfeld 20-35% of the land is irrigated annually due to crop rotation. The most used system is the hand-moved sprinkler system or the permanent sprinkler system with small drops, which prevent delicate crops from damage. However, the use of the travelling gun systems has increased in the last decade. This system has higher initial costs but a lower labour requirement. It should only be used on crops which tolerate land drops and a higher application rate. (NEUDORFER, 2006)

The irrigation in the Marchfeld is mainly established on small-scale irrigation plants where nearly every plots has its own well and pump to take out groundwater. In addition companies have been established to reduce operating costs for the farmers. There are costs for operation from 0, 1 to 0, 2€ per m3 irrigation water. Recently farmers start to lower their costs by exact application of irrigation water, measuring the soil moisture to control the water requirements.
In Addition, there exist a maximum of annually irrigation for every crop, which is not allowed to be exceeded. Moreover, to avoid eluviation of nutrients, farmers shall give small and single amounts of groundwater, which is up to soil physics and is fixed by maximum 30 to 40mm. (KATZMAYER, 2003)

Optimizing irrigation water means less drought stress for plant growing and at the same time minimizing groundwater pollution by nitrates. (NEUDORFER, 2006)

One reason for the irrigation is moving of the precipitate sum during the last centuries. This graph shows the total precipitate for each month from 1960 till 2005 in the Marchfeld.
As you can see precipitate in the year 2005 in July and August was doubled up than 5years ago, but on the other hand in March it was 7 times lower than in the year 2000.



More than 270 farmers from Marchfeld work contract-based for the frozen food producer Frenzel Austria Frost GmbH. Since 1965 this recently taken over enterprise provides 80% of Austria with frozen vegetables.(www.wikipedia.at) and recently processes about 35.000 tons of raw vegetables and is going to widen its pea, bean and spinach production. (Grüner Bericht 2005) Products have a high nutritional value as a consequence of minimal processing.

Many conventional farms in Marchfeld ensure the sale of their products in contracts and commit themselves to defined crop. This situation is unbearable for farmers, who toy with the idea to convert to organic farming, contributing to biodiversity and protection of resources. Another reason for the small amount of organic farms in this region is the absence of appropriate marketing and distribution channels of organic products for numerous big farms. Direct marketing is also uneligible for selling big amounts of products, at that it´s time-consuming. (HADATSCH, 2000)
From the point of farmers, protecting species and habitats is often business for nature conservation and not for agriculture. Furthermore careful observation of success and breakdown of organic farmers on the part of intensive agriculture retard willingness of conversion of production. (HADATSCH, 2000)

As it is already mentioned, resiliency is the capability of a system to maintain its functions and structures in the face of internal and external change and to degrade gracefully when it must. There may be a number of opportunities to implement resiliency strategies for a system like the food production area of Marchfeld. In general, a portfolio approach based on managing a number of varying risks should be the most efficient. The portfolio approach is also desirable given the difficulty of unambiguously defining risk and thus investments in resiliency. This ambiguity also serves as an argument for investment to enhance resilience against attacks, disaster and climate change and provide additional economic, social, or environmental benefits. These dual technologies are important, due to resource limitation but also because they enhance long-term security and therefore resilient societies as well. Fragile communities are more likely to be susceptible to disaster or attack or external changes like climate change when such events occur and more likely to experience subsequent weakness and failure in the aftermath of abrupt change or attack. (ALLENBY, 2005)

Analysing the food production system in Marchfeld, its status of sustainability and capability, regarding the whole process chain from agriculture to transport to processing and distribution on markets as a union like an enterprise is necessary.

Scenarios

Let us focus on future scenarios and how climate change will challenge agriculture and food production.
The potential future impact of climate change on global food production and food security has been studied using a combination of climate model simulations, crop models, and world food trade system models. Using simulated climate under different future scenarios of the Intergovernmental Panel on Climate Change, scientists found out, for the most part, the world would continue to feed itself under all climate change scenarios. However, this global outcome arises in increased production in developed countries compensating for the decrease in developing countries. Besides, growth rates in food production are slowing from 3% per year in the 1960s to 2% from 1982 to 1992 (LAMBIN, 2006) and local- to regional-scale food shortages continue to persist. (LAMBIN, 2006)

In 2002 scientists estimated in how far expected climate change will affect antecedent soil-moisture and as a consequence growth of plants and fruit. They simulated two typical crop rotations in Marchfeld using six different scenarios and the deterministic simulation model SIMWASER computing soil-water balance. They reproduced the actual state over the specific time period 1987-2003 for the crop rotation sugar beet - fall wheat – potato – fall wheat – spring barley, and ground water balance. Afterwards they simulated consequences of climate change to crop rotation using key surface and atmospheric variables from the scenarios anticipating a general rise in output increase of 30% for all crops as a consequence of CO2 increase appointing to the Center for the Study of Carbon Dioxide and Global Change (2004).
Calculation showed a rise in output for crops which grow on Tschernosem of 0 – 20% and for Paratschernosem, a soil type with comparatively less storage capacity and therefore less output. (STENITZER, 2004)

Which kind of extreme weather bad harvests causes is the central question of ARC Seibersdorf research, which analysed 7 agricultural crop species in 3 regions of Austria. Winter wheat, spring barley, corn, sugar beet, potato, grapevine and apple were analysed based on data consisting of area-based agro-statistical surveys and the monthly means of meteorological parameters from 1869 to 2002. Outcomes shall help to assess, which kind of crops are most vulnerable to extreme weather events, happening in a specific time of season. Together with more realistic future scenarios for Austria, results shall help to estimate which kind of crop will benefit from climate change and what kind of crop is supposed to bring out more bad harvests. (SOJA, 2003)

Considering the crucial role of sugar beet in Marchfeld, findings from sugar beet production are going to be discussed.
In the 20th century production of sugar beet in Marchfeld made a sum of 10 to 20t/ha..
Recently, average output reaches about 70t/ha, whereas production area has been expanded.
Minima of temperature below average in the period from April till July hindered optimal growth. However, bad harvests are closely linked to little appearance of highest temperatures in the first part of vegetation period and a lot of as of August. This temperature-sensitivity of sugar beet points at the appropriate heat demand of this crop, otherwise youth development

will be retarded. Bad harvests came along with humid growing and dry periods in August and September. Around August sugar beets tend to gain a lot of biomass and therefore plants need a lot of water. (SOJA, 2003)

"It is important to be aware that predictions from climate models are always subject to uncertainty because of limitations on our knowledge of how the climate system works and on the computing resources available. Different climate models can give different predictions". To incorporate this statement as it is written on the homepage of UK's national meteorological service (www.metoffice.com),

The scenarios were constructed to support analyses of the vulnerability of ecosystem services, but the approach also provides an exploration of how agricultural land use might respond to a range of future environmental change drivers, including climate and socio-economic change. (www.metoffice.com)

Agricultural production can be described in terms of amount and quality.

Literaturverzeichnis:

Walker, B.; Carpenter, S.; Anderies, J.: Resilience Management in Social-ecological Systems: a Working Hypothesis for a Participatory Approach, The Resilience Alliance, 2002

Kromp-Kolb, H.; Die Landwirtschaft im globalen und regionalen Klimawandel. Bericht ALVA Jahrestagung 2004, Wien, 8 – 11

GROOM, M., J.; MEFFE, G., K.; CARROLL, C., R. et al (2006): Habitat Degradation and Loss in: Principles of Conservation Biology, Sinauer Associates, inc., Sunderland, MA 01375 USA, 184

SHAH, M., M.; FISCHER, G.; VAN VELTHUIZEN, H.; Food, Water, Health and Climate Change. Institute for Applied Systems Analysis, A 2361 Laxenburg, Austria

FISCHER, G.; SHAH, M., M.; VAN VELTHUIZEN, H.; Climate Change and Agricultural Vulnerability. Institute for Applied Systems Analysis, World Summit on Sustainable Development, Johannesburg, 2002

NESTROY, O. (1973): Landschaftsökologische Untersuchungen im Gebiete des Marchfeldes; Wien: Österr. Agrarverlag. In: Wo i leb… Kulturlandschaften in Österreich, Katalog Nr. 67 des Stadtmuseums Linz-Nordico, 1997

HADATSCH, S. et al: Biologische Landwirtschaft im Marchfeld. Umweltbundesamt GmbH, Wien, 2000

VABITSCH, A.: Bewertung landwirtschaftlicher Bertriebe im Marchfeld mittels Umweltindikatoren. Institut für Ökologischen Landbau, Universität für Bodenkultur Wien, Wien, 2000

ÖSTAT (1995): Betriebszählung, Agrarpreisstatistik, Frucht- und Kulturarten der Gerichtsbezirke Gänserndorf, Marchegg, Großenzersdorf. Zit in: BUBENICK, B. (1997): Quantifizierung der Ausgaben der öffentlichen Hand zum Schutz der natürlichen Ressourcen von Wasser und Boden als dominante Produktionsfaktoren im Marchfeld. Diplomarbeit. WirtschaftsUniv., Wien.

NEUDORFER, W.: Tendencies in the Field Irrigation as shown in the Example of the Region Marchfeld in Austria. Soil Physics and rural Water Management – Progress, Needs and Challenges. Proceedings of the International Symposium SOPHYWA, Vienna 2006

ÖSTAT (1997): Agrarstrukturerhebungen 1995. Gesamtergebnisse über die Land- und Forstwirtschaft, ÖSTAT, Wien

KATZMAYER, H.; RENNERT, G.: Bewässerung in Niederösterreich. Fachtagung der DLG-Arbeitsgruppe Feldberegnung, Amt der NÖ Landesregierung. Abteilung Wasserbau,3109St. Pölten, Austria, 2003
LAMBIN, E., F.; GEIST, H., J.: Multiple Impacts of Land-Use/Cover Change, in: Lan-Use and Land-Cover Change – Local Processes and Global Impacts, Springer-Verlag, Berlin Heidelberg, Germany, 2006
STENITZER, E.; HÖSCH, J.: Die Auswirkungen der Klimaänderung auf den Bodenwasserhaushalt und die Erträge im Marchfeld – eine Simulationsstudie. Bericht ALVA Jahrestagung 2004, Wien, 37-40
SOJA, A-M.; SOJA, G.: Dokumentation von Auswirkungen extremer Wetterereignisse auf die landwirtschaftliche Produktion, Teilprojekt von StartClim, „Startprojekt Klimaschutz Erste Analysen extremer Wetterereignisse und ihre Auswirkungen in Österreich“, Austrian Research Centers, Wien, 2003
ALLENBY, B.; FINK, J.: Toward Inherently Secure and Resilient Societies, Science, 309;1034-1036, 2005

http://de.wikipedia.org/wiki/Eskimo-Iglo,(Stand: 28.10.2006)
http://www.maweb.org//en/Products.Synthesis.aspx, (Stand: 27.10.2006)
http://www.metoffice.com/corporate/pressoffice/2002/pr20020426.html (Stand: 30.10.2006)

Curriculum Vitae

PERSONAL INFORMATION

Name	Katja Bohländer
Date of Birth	04.02.2012
Place of Birth	Vienna
Citizenship	Austria

EMPLOYMENT HISTORY

Since 2012	Self-employed as Shiatsu Practitioner
2007	Internship within the project „Ernährungsrisikopatienten in der geriatrischen Langzeitbetreuung“
2007	Internship as assistance in preparing and caring out the “NutritionDay in European Hospitals 2007”
2006	Internship within the project „Ernährungsrisikopatienten in der geriatrischen Langzeitbetreuung“
2005	Internship at Josef Manner & Comp. AG (food quality control)
2003 to 2011	Personal assistance for disabled people
2002 to 2004	Assistance in communication of art, MUMOK
2002	Participation in the environmental campaign “Pestizide. Kein Gift in unserem Essen”, GLOBAL 2000

2000 to 2002 Market and opinion research, Integral Markt und Meinungsforschungs GesmbH

1998 and 1999 Vacation employment at Josef Manner & Comp. AG

EDUCATION

Since 2012 Training in Chinese dietetics

Since 2000 Diploma studies at the Department of Nutritional Sciences

2007 to 2011 Training in Shiatsu, certified graduate

1992 to 2000 Secondary school, higher school certificate

1988 to 1992 Primary school

PUBLICATIONS

PAULESICH R, BURGHART H, BOHLÄNDER K, HASLBERGER AG. Assessment of Resilience of agro-ecological and social System in Vienna Region in Response to Climate Change using an Integrated Model. Discussion Paper for the Open Science Conference of the Earth System Science Partnership, Bejing, China, 09.11. – 12.11. 2006, 2006c

PAULESICH R, BOHLÄNDER K, HASLBERGER AG. Integration of resilience into sustainability model for analysis of adaptive capacities of regions to climate change: the EASEY model. In: Sustainable food production and ethics. Preprints of the 7th Congress of the European Society for Agricultural and Food Ethics EurSAFE 2007 (ZOLLITSCH W, WINKLER C, WAIBLINGER S,HASLBERGER AG, ed). Wageningen Academic Publishers, Vienna, 2007b; 145-150