Agroecological System Analysis of the Krishna- Valley in Hungary

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Preface and acknowledgements

This thesis work has been written for the completion of the double degree Msc. Organic Agriculture (Wageningen UR) and Msc. Agroecology (ISARA- Lyon) during the years 2013 and 2014. This thesis was inspired by and is based on the methodology of the Msc. course Analysis and Design of Organic Farming Systems hosted by the Farming Sytsems Ecology group of Wageningen University. I believe that with the completion of this programme it is not only a degree I gained, but also a mentality of professionalism, accuracy and the capability to approach complex questions with interdisciplinary thinking. I would like to thank all the teachers of the double degree program for this most inspiring experience.

When I first visited Krishna- Valley in 2012, I was fascinated by the harmony in which Krishna devotees live their lives with nature. It was a very inspiring experience to gain insight into all the little details of farming, natural resource management and their role in the everyday lives of inhabitants. It is my hope that this agroecological analysis can be of help during the continuous and never- ending development of Krishna- valley.

I would like to thank my two official supervisors, Jeroen Groot and Jacques Godet for their continuous help and support during this thesis work. I would also like to thank my Krishna- valley supervisor, András Kun for helping me gather all the information needed for my research. Many thanks to my interviewees Radha- kanta Das, Partha Das, Balamodaka Das, Antardi Das and Ghanasjama Das for sharing with me their experiences and insights about life, nature and agriculture in Krishna- valley. Last, but not least, I would like to thank my family and friends for their support and patience during the lengthy process of writing this thesis.

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List of abbreviations

EII: Ecological infrastructure index
EIM: Ecological infrastructure management
FSI: Field size index
GEN: Global Ecovillage Network
GP: Grazing period
IFOAM: International Federation of Organic Agricultural Movements
ISKCON: International Society of Krishna- Consciousness
KSH: Hungarian Central Statistical Office
MEH: Network of Hungarian Living Villages
MVOAI: Maharishni Vedic Organic Agriculture Institute
NGP: Non- grazing period
SOM: Soil organic matter

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Abstract

The Krishna- valley ecovillage was founded in 1993 in Hungary with the aim to form a spiritually devoted community that is capable of reaching self- sufficiency for food, fuel and fibre. Being the largest ecovillage in Hungary and a spiritual centre for Krishna-consciousness, over the years Krishna- valley has become a venue for tourism, pilgrimage and knowledge sharing. An agroecological system analysis was carried out in order to study the components, management practices and their social- spiritual context of agriculture in a model settlement for sustainable living practices and self- sufficient, organic agriculture. With the emphasis on an individual farming system analysis in the context of the social conditions and needs affecting the current structure of the agricultural system; the compliance of the farming system with these needs and permaculture principles were analysed. Information was gathered through literature research, a six week long field visit including semi- structured interviews with department heads and email correspondence. The information was analysed qualitatively concerning social- spiritual context, agroecological components and practices. Quantitative data was analysed and optimization of problematic aspects was carried out with FARMDesign. Spatial analysis was performed with LandscapeLab. The spiritual and socio-economic context of Krishna- valley strongly affects the expectations of and demands on agricultural production. The most important spiritual guidelines were identified as forming an aggression free society, leading a life in harmony with nature and a in a materialistically simple manner. Major findings of productive farm performance analysis suggest, that the current system is capable to maintain high levels of N, while mining the soil for P and K and exporting C with crop products. SOM levels could be in balance, provided a 1% yearly degradation. Improvement of soil nutrient balances by modelling was possible through raising crop areas of cereals and alfalfa. Results for calculating field size index and ecological infrastructure index show that the field sizes and the ecological infrastructure are more than optimal for supporting functional biodiversity and the dispersal capacity of natural enemies. Landscape modelling showed, that land- use in Krishna- valley is more diverse than its surroundings. The synthesis process showed, that while some qualities of the agroecosystem are in harmony with the social and spiritual expectations, others present a discrepancy. Internal cycles of products and services are capable of meeting certain aspects of self-sufficiency, while external inputs are needed to provide goods for material needs and supplement internal processes. Social demands are met with a farming system capable to serve the community's needs for crop and animal products for consumption in accordance with spiritual requirements. The continuous development shows adaptation to permanent geographic and natural conditions by applying organic farming methods and ecological infrastructure management, but also adaptation to changing climatic conditions is influenced by the diversity of crops and natural elements in the system.

Keywords: *ecovillage; agroecology; system analysis; organic agriculture*

1. Introduction

1.1. Research Context

1.1.1. Organic agriculture and sustainable farming systems

Defining organic agriculture and sustainable farming systems

Over the last decades of agricultural industrialization, a great increase in agricultural production could be observed, resulting in a large amount of widely available agricultural products (Tilman et. al. 2002). However, the high rates of global agricultural output and consumption often result in detrimental effects to the environment and social systems. Industrial agriculture had negative side effects on natural ecosystems and environmental pollution, while being highly dependent on non- renewable resources and production subsidies (Rigby and Ceseres, 2001). The distribution of the benefits of these highly productive systems among the population is unequal; the external costs of productivity are often paid by those with no access to the benefits (Trainer, 1997).

For long term sustainability, agricultural systems should be "environmentally sound, resource- conserving, economically viable and socially supported" (Rigby and Caseres, 2001). This approach to agricultural sustainability emphasizes the need to analyse and improve agricultural systems not only on the agronomic, but also on the environmental, social and economic levels, which is often not the case in modern agricultural research. Pretty (2008) identified the key principles of agricultural sustainability as (1) the integration of biological and environmental processes into agricultural production, (2) minimizing the dependence on non- renewable resources, (3) improving self- reliance by building on local knowledge, (4) building on communities, (5) raising multifunctionality of the agricultural system, and (6) using locally adapted technologies. Adapting these key principles in agricultural production results in the development of technologies and practices that lead to improvements in food production without compromising environmental goods and services (Pretty, 2008). Although organic agriculture should not be equated with sustainable agriculture, since in certain cases it can also have adverse environmental effects (e.g. Leifeld, 2012), most of the basic principles of organic agriculture are in accordance with the principles of sustainable agriculture described by Pretty (2008). The term "organic" refers to seeing the farming system as a living system, in which the qualities of the system are the result of the interactions of its components (IFOAM, 2012). Organic farming aims to maximize internal nutrient cycling, thus reducing reliance on external resources, while managing ecological and biological processes to the benefit of the farming system and its environment (Rigby and Caseres, 2001). The main objectives of organic farming and generally applied methods to reach these objectives are summarized in Table 1.

Table 1. Main objectives of organic farming and generally applied methods to meet these objectives (summarized after IFOAM, 2012; Pretty, 2008; Stockdale et. al, 2001)

Objective	Methods
Protect long term biological, chemical and physical soil fertility	• Reducing erosion by maintaining soil cover: leaving crop residues on the field after harvest, sowing winter crops and green manures, mulching • Fostering soil biological diversity and activity by reducing soil disturbance: low or no- tillage, planned timing of mechanical activities • Tightening nutrient cycles by reducing losses and recycling organic materials: manure application, composting, timing of application

	• Applying wide crop rotations to eliminate unilateral mining of nutrients • Including N- fixing legumes in the rotation
Control weeds, diseases and pests	• Applying wide crop rotations to avoid accumulation of specific pests • Intercropping and use of beneficial plant associations • Enhancing biodiversity to favor the activity of natural enemies and competition by preserving natural habitats and excluding chemical pesticides and herbicides from the production • Use of resistant and locally adapted plant and animal varieties
Minimize adverse environmental effects	• Reducing environmental losses by minimizing erosion, leaching and volatilization • Excluding chemical fertilizers, pesticides, herbicides and antibiotics from the production • Increase robustness and resilience of the system by raising its complexity

Maintaining soil fertility

Maintaining and improving soil quality in the long term is essential for agricultural systems that do not rely on external resources for nutrient supply. Soil organic matter (SOM) is considered to be one of the most important indicators of soil quality and productivity. SOM availability in soils directly contributes to crop productivity, but indirectly it also plays an important role by affecting microbial activity, water infiltration and physical properties of the soil, such as bulk density or aggregate stability. SOM dynamics is influenced by inputs of fertilizers and manures, rotation design and management practices (Reeves, 1997). Management practices, that disturb soil for example, prone to increase SOM degradation and lower SOM content (Balesdent & Balabane, 2000).

A crop rotation is a consciously designed sequence of crops, which plays a central role in preserving biological, physical and chemical soil fertility on the long term. Multifunctional crop rotations should take into account the contribution of crops to soil fertility and their effects of growing conditions of subsequent crops. Maintaining and improving soil fertility in organic farming relies to a large extent on nutrient dynamics between crops and the soil in consecutive years, therefor nutrient demand of and nutrient transfer between crops has to be taken into account when designing rotations (Haan & Diaz, 2002). Atmospheric nitrogen fixed by leguminous crops is a significant resource in organic farming, where artificial fertilizers are not present. Leguminous crops can be grown as main crops, in mixture with grass or as green manure that is incorporated into the soil (Watson, 2002). Other non-leguminous crops incorporated into the soil as green manure can also play a role in increasing soil organic matter, microbial activity and suppression of plant diseases (Abawi, 2000)

The effect of crop rotations on crop protection relies on the ability of certain crops to create unfavourable conditions for pests and weeds and changing soil microbial composition influencing pests (Watson, 2002). The crop selection of species and varieties has to take into account the effect of climatic conditions, timing of management, and labor demands (Haan & Diaz, 2002).

Agroecology and the call for a system approach

The scientific discipline of agroecology emerged in the early 20th century as the study of crop production systems in an ecological context. In the last 30 years however, agroecology developed into a scientific principle of different scales (field, agroecosystem, food system) mostly focusing on designing and managing sustainable agri- food systems.

Since the modern discipline of agroecology is rooted in developing sustainable food systems, its core principles are very similar to those of sustainable and organic agricultures described above. Besides the scientific principle, agroecology can also refer to the agricultural practices and social movements associated with such sustainable systems**.** By raising the discipline from the field level to the level of the whole food system, research in the area requires trans-disciplinary approaches and methods from the fields of ecology, agronomy, economics and sociology (Wezel et. al., 2011).

A trans- disciplinary approach integrates scientific and local knowledge systems and has a problem based focus. In contrast with classical agricultural research, this approach shifts the focus from technological questions and adopts a systemic view. Agroecological research allows for combining the different contexts of sustainability (ecological, social and economic) resulting in an understanding of farming systems as learning systems in coevolution with their environments. (Sriskandarajah et.al., 1991)**.** In this understanding, an agroecological approach to research will be holistic, consider the farming system in its socio- economic, ecological and environmental contexts. This results in a focus on interactions between components, such as energy and nutrient cycling, synergistic processes between biotic and abiotic components and the role of human activity in such processes (Altieri, 2002; Tomich et.al, 2011; Méndez, 2013).

Ecological Infrastructure Management

An agricultural landscape is defined by the land- use of agricultural production, such as types of crops, management practices; but also by the spatial arrangement of non-agricultural landscape elements (Baudry, 1993). Ecological agriculture has a holistic approach that makes use of the interactions between agricultural and other landscape components. If studying the agricultural system as an ecosystem, the central concept of stability needs to be studied. Stability can be expressed by three parameters, such as resistance, resilience and persistence. These parameters cover the ability of the system to remain unchanged during stress, the ability to return to the original state after disturbance and the ability to remain unchanged over time It is a general agreement, that stability will be higher in functionally more diverse systems, therefor sustainable agricultural systems must be designed to build on the ecological constituents and their interactions (Phelan, 2008).

Ecological networks are a connected set of natural and semi- natural elements in a landscape that can provide shelter and alternative food sources for natural enemies of pests and thereby enhance natural pest control in agroecosystems. The effectiveness of pest control provided by the landscape elements in an agroecosystem relies on the spatial structure of the ecological network and the quality of flora present that enable natural enemies to reach their prey (Steingrover et. al. 2010). A mosaic like landscape structure shows a higher biomass and diversity for insects that could be beneficial for crop production. A mosaic like structure means that larger fields are divided by various landscape elements, such as woody shelterbelts, meadows and water elements. Herbivorous insects that can appear as pests in an agricultural landscape rely more on the availability of food than the presence of refugees. On the other hand, predators and parasites benefit more from the presence of refugees, such as natural elements and their abundance is more connected with the heterogeneity of the landscape. It is for this reason that a mosaic like agricultural landscape will provide higher pest control than a homogenous landscape (Baudry, 1993). Natural enemies show active and passive movement throughout the agroecosystem, while pests are more sessile (Steingrover et. al. 2010). The structure of landscape elements need to enable recolonization of smaller patches after disturbances, therefor the connectivity of these elements needs to be taken into account when analyzing pest suppression capacity of a landscape (Bunce and Jongman, 1993). Managing the ecological infrastructure has other objectives besides natural pest control, such as increasing local biodiversity, creating an attractive landscape for the community, reducing losses in the agroecosystem or increasing benefits of physical conditions (Hopster and Viser, 2002).

The result of human action and natural processes is the landscape, which is an area perceived by people. Landscape identity is the result of both human perception of the area and the effect of interaction between physical, natural and human processes. This interaction has to be studied from the viewpoint of both the effect people have on the landscape and the effect the landscape has on people. A landscape can be understood as a result of several different identities that influence its properties.

Geographical identity helps to typify a certain landscape by its geographical properties. The geographic identity is consciously strengthened by continuous research in land-use history and restoration of traditional landscape components. Existential identity refers to the attachment that people have to the landscape in which they live. Another type of division of landscape identity can be made between what a landscape holds for an individual and the community, the personal and the cultural identity.

Coherence is the relation between the landscape system and the landscape image perceived by people. The legibility concept emphasizes, that the more coherence between the landscape and its perception there is, the more legible the landscape is, because site and time specific features are present. Vertical coherence refers to the local natural properties, such as soil, geomorphology and water, while horizontal coherence refers to the relation between functional and landscape ecological components. Seasonal coherence is the expression of the moment of the year in the landscape, while historical coherence refers to the expression of a time of history by specific sites and mementos. The stronger these four types of coherences, the stronger the legibility of the landscape.

1.1.2. Ecovillages

Ecovillages: In- vitro sustainability?

The tendency, that while some are posing causeless demands, others cannot even meet their basic needs was identified as the basis of social inequity by Gyulai (2012). In this context, needs are those construable resources needed by an individual to survive and lead a dignified life, such as water, food, clothing, housing, access to education and healthcare. Demands, on the other hand are differing among individuals, cannot be generally specified and exceed the needs for survival. Modern economic thinking sees raising income and production as the only way to meet the demands and needs of rich and poor, but the problem is, while there is no limit to the growth of demands, there is a limit to growth of production (Gyulai, 2012). According to Trainer (1997), to reduce global social inequity and form sustainable societies, unjustified demands should be reduced; individually this means that lifestyles should be materially simplified with the focus on the concept of self-sufficiency. At the level of the society, development of small scale and self-sufficient local economies, with local sources for products and highly developed cooperative systems would be favourable (Trainer, 1997).

An ecovillage is defined by the Global Ecovillage Network as “An intentional or traditional community that is consciously designed through locally owned, participatory processes to regenerate social and natural environments. The 4 dimensions of sustainability (ecology, economy, the social and the cultural) are all integrated into a holistic approach.“ (GEN-Europe, 2012a). Ecovillages are intentional communities, meaning its members come together deliberately for a shared purpose, which always includes the commitment to drive positive social changes and adapt a low-impact lifestyle (GEN- Europe, 2012; Liftin, 2009). Although ecovillages are diverse in size, geographical distribution, religious worldview and the applied practices, they share the common aim of long term sustainability and have become a global movement that was institutionalized by the formation of the Global Ecovillage

Network in 1995 (GEN – Europe, 2012b). The Hungarian ecovillage movement started around the time of the shift from communism to market economy in 1989, most of the ecovillages which are members of the MEH (Hungarian Network of Living villages) were founded in the early 1990s. The common goal of these settlements is to develop a sustainable village model, provide healthy lifestyles and live in harmony with nature (Cake- Baly, 2009). Currently, there are between 10- 15 ecovillages in Hungary, depending on definition, from which 4 villages are member of GEN (Háry, 2008).

The concept of permaculture, a design concept for agriculture, was originally focused on creating guidelines for "permanent", family- scale agricultural production and household systems. Permaculture adapts a system approach of farming-household systems with an emphasis on cyclical processes, reducing energy losses and designing systems inspired by natural processes. In the agricultural sense, these implications are similar to and even included in the organic agricultural principles. However, it goes further in its social implications, raises the awareness of the importance of the social factors in the system, takes an integrated approach at architecture, environmental production, economics, technology, health and education. The original permaculture approach was raised from the family to the community-scale by the ecovillage movement and it continues to define its basic principles (Liftin, 2009).

Krishna- valley

Krishna valley was founded in 1993 by the Hungarian Community of Krishna Consciousness with the aim to develop a self-sufficient farming community in accordance with ancient vedic scriptures and the guidelines of the International Society for Krishna Consciousness (ISKCON, 2013). In the last 20 years, the Krishna- valley developed to be the largest, one of the most complex ecovillages in Hungary, with an area of 270 hectares and 150 inhabitants (Kun, 2012, pp. 40-49). The aim of the ecovillage since the beginning was to create independence from the outside world, reach self- sufficiency to the highest degree possible and meet all of the needs of the community in a sustainable manner according to spiritual guidelines: food, clothing, healthcare, education and living. Agricultural production is practiced in harmony with the teachings of Krishna and in a wider context, with the Hindu worldview, which considers planet Earth the mother of all living things. Therefore all human activity must be respectful towards nature, which results in the lack of chemical use and the application of placid, ecological farming practices. Ancient vedic scriptures have several implications for farming, which give the major guidelines for farming in Krishna- valley, however, specific farming practices were developed based on the more recent knowledge in traditional peasant farming, organic agriculture and permaculture (Okovolgy, 2008a). Krishna devotees lead a strictly lacto-vegetarian lifestyle, which means their diet is mostly plant based with addition of dairy and apiary products. Cows are holy animals in all branches of Hinduism, they are praised and respected by the community as individuals, their services, such as milk and work- power are accepted, but never forced (Lánczi, 2009). The spiritual background and the dietary habits of the Krishna valley inhabitants resulted in a complex organic agricultural production system that needs to meet the community's needs for cereals, legumes, oil- seeds, vegetables, fruit, milk- products and honey. To raise independence from external resources and to reduce environmental impact, Krishna valley aims at being a mineral oil free community with a high reliance on animal power for agricultural management (e.g. ploughing) and food processing (e.g. milling of cereals) (Kun, 2012, pp. 44-49).

Meeting the goals of self- sufficiency and sustainability can be demonstrated by results of previous research carried out in Krishna valley. Krishna valley is 25% self-dependent for firewood, provides 100% of its inhabitants' cereals and legumes, produces 50% of its vegetables and 80% of the needed fruits. Although not yet 100% self-sufficient in terms of food and energy, these values are exemplary for small village communities (Lánczi, 2009). Krishna valley inhabitants have an ecological footprint of 1.4 ha/ capita, while the Hungarian average is estimated to be between 3.5-4.5 ha/capita. This result implies that the methods and practices for a low-impact lifestyle applied in the Krishna valley are fairly successful (Lánczi, 2009).

Krishna- valley has a long history of cooperation with research and educational institutes in Hungary. By 2013, 70 university students have carried out or started research and written a thesis work about different aspects of life in the Krishna- valley. Topics range from theology, sociology and anthropology to agronomic, horticultural and environmental research. Agricultural research focuses mainly on finding resilient plant varieties and using different preparations for raising nutrient availability and pest control. However, the research efforts so far have lacked a systems approach that focuses on agricultural production (Ökovölgy, 2012b). In 2012, Ecovalley Foundation published a book of interviews with the title "Conversations about self-sufficiency" (Kun, 2012), which gives a good insight into the large diversity of organic agricultural practices and the spiritual background of farming in Krishna valley. However, since the book was intended for the wider public with the aim to raise awareness, it fails to deliver a complex picture of the interrelation of social, economic, spiritual, agronomic and environmental aspects of agricultural production in Krishna- valley. As a highly self-sufficient community with a low-impact lifestyle, understanding the agricultural system in the context of the ecovillage could be beneficial for developing self-sufficient communities in the future.

1.2. Purpose and structure of the study embedded in theoretical framework

The aim of the study that was carried out in Krishna valley was to understand agricultural production in its social and environmental context, while delivering an analysis of interrelations between agricultural methods and practices and mapping the network of nutrient and energy flows. After carrying out the analysis, weaknesses and strengths in the farming system were diagnosed, resulting in implications for improving the farming system and future research.

The theoretical framework for the study is based on the "Analysis" step of the Prototyping Approach proposed by Haan and Garcia Diaz in the VEGINECO project (Haan and Garcia Diaz, 2002), which was selected, because it offers a good framework for a multidisciplinary analysis and several applicable methods and indicators. Qualitative methods of the prototyping approach were used to analyse social demands towards agriculture and the agroecological properties of the farming system. Quantitative methods were used primarily to characterize the farming system in terms of nutrient flows, labour and ecological infrastructure management.

With the emphasis on an individual farming system analysis in the context of the social conditions and needs affecting the current structure of the agricultural system; the compliance of the farming system with these needs and permaculture principles were analysed. (Figure 1). Due to the short time available for the research, the steps of "Redesign", "Testing and Improving" and "Dissemination" were not carried out, thus the prototyping process was not completed. Due to the small number of ecovillages and lack of available data, the sectorial statistics was replaced by a qualitative description of the ecovillage sector in Europe in the context of organic agriculture, sustainability, spirituality, society and the economy. Since the Krishna- valley is not primarily aimed at high economic productivity and functions fairly isolated from wider environment, social demands described in the VEGINECO model will be adapted to a series of more internal social demands towards agriculture, such as complying with spiritual guidelines and reaching self-sufficiency. After the analysis is carried out, the end- point of the thesis will be a SWOT analysis and a problem tree, thus leaving open questions for future research.

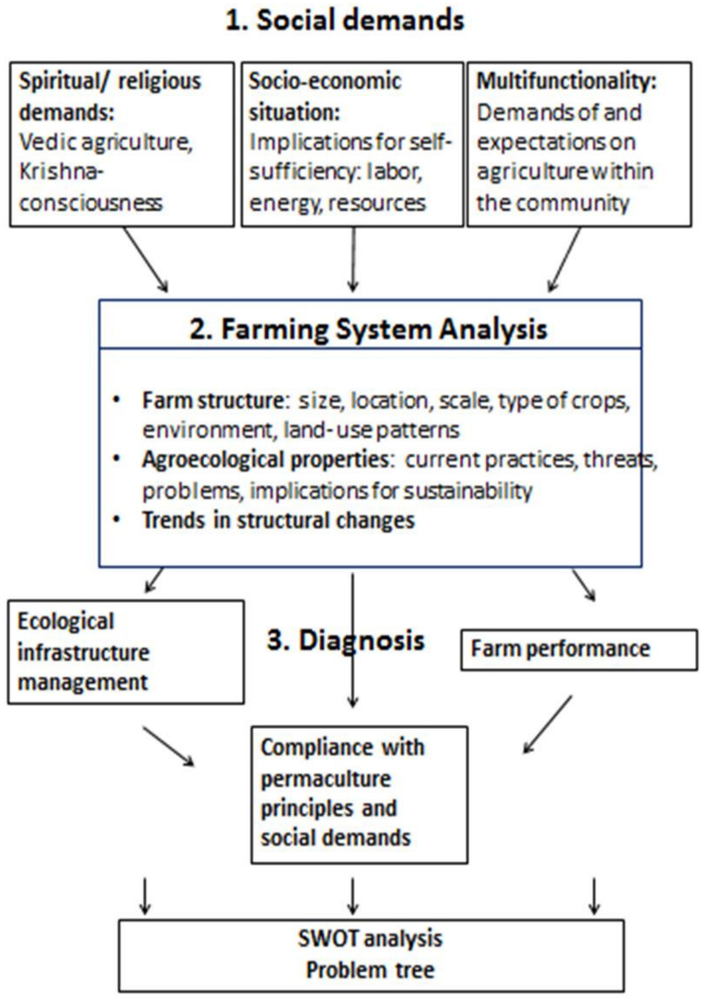


Figure 1. Theoretical framework for the farming- system analysis (developed after Haan and Garcia Diaz, 2002, Groot et. al., 2012)

Complying with the theoretical framework described above, the study is composed of the following structure of the thesis work. Components of the thesis and related research questions, methodology, parameters, and result are summarized in Table 2.

Table 2. Components and main research questions of the study with implications to methodology, indicators and parameters and type of results

Component	Research Question	Methodology	Indicators/ Parameters	Result
STEP 1 Explore social context/ demands	What are spiritual/ religious demands towards agriculture? What are the implications of vedic agriculture and Krishna consciousness?	Literature review Field visits Semi structured interviews	Not applicable	Descriptive qualitative summary of spiritual context of agriculture in Krishna valley
	What are the implications of social-economic situation towards agriculture, such as labor, resource use, energy use and self- sufficiency?			Descriptive qualitative summary of the socio- economic situation of Krishna valley
	What are the expectations of and demands on agriculture in Krishna- valley?			Descriptive qualitative summary of the role of agriculture in Krishna valley
STEP 2 Farming system analysis/ description	**Farming structure:** How can the geography and environment of the farming system be described in time and space?	Fieldwork Records of development Semi structured interviews	Size, land type, soil properties, environment, climate	Qualitative and quantitative summary, timeline of changes, maps, tables
	What is the composition of crops and cattle in time and space?	Fieldwork Records of production Semi structured interviews	production areas, composition of cattle	Qualitative and quantitative summary, timeline of changes, maps, tables
	Agroecological properties: Which agricultural components and practices can be identified, what are their properties?	Fieldwork Semi structured interviews Records of production	type, role and importance of components, yields, cattle composition, production records	Qualitative and quantitative summary, timeline of changes, maps, tables
	How are the components and practices interrelated in solving questions of nutrient management and pest control?	Fieldwork Semi- structured interviews	management practices, timing, labor, energy, nutrient balances	Qualitative and quantitative summary, timeline of changes, tables and figures
	What are the components and practices of ecological infrastructure management?	Paper based mapping and analysis Semi- structured interviews	landscape structure, management practices	Land- use map Qualitative and quantitative summary
STEP 3: Diagnosis	What are the indications of the results in means of productive farm performance?	FarmDESIGN	Distribution of areas in rotations, crop yields, product destination, feed evaluation, organic matter and nutrient balances, labor	Quantitative summary with tables and figures

	How does the farming system perform in ecological infrastructure management? What are the implications for integration of the farm into the surrounding landscape, raising species diversity on the system level?	Paper based mapping and analysis Analysis with LandscapeLab	Percentage woody elements, connectivity of landscape elements, biotopes	Land- use map Results for parameters and comparison with guidelines and the expressed strategy of management
	What do the results imply in comparison with recent literature?	Comparative literature study	Crop areas, yield records, agricultural practices	Discussion
STEP 4: Synthesis	How does the agricultural system in Krishna- valley comply with agroecological principles and the social demands towards agriculture? How are the biophysical and social components of the agroecosystem interrelated?	Analysis of previous results (Analysis, Landscape Lab, FarmDESIGN, Discussion)	Not applicable	Descriptive qualitative summary
	Which are the strengths and critical points of the farming system?	Analysis of previous results: System analysis, LandscapeLab, FarmDESIGN,	Not applicable	SWOT analysis

2. Materials and methods

Data collection

The data for the qualitative and quantitative analysis was collected between October 2013 and January of 2014. A field study was carried out during the first three weeks of October, during which six in- depth qualitative interviews were recorded with directors and department leaders of agricultural production components. During the field study, mapping of landscape use of Krishna- valley was carried out with the help of the interviewees. Several local museums and collections were visited to get familiar with the history, culture, geography and ecology of the region. After the field visit, missing quantitative data was acquired through email correspondence. Photographic documentation was carried out throughout the visit, a photo gallery can be found in Appendix 1.

Analysis

Analysis of the social demands and farm structure was carried out by literature study and semi-structured interviews during the fieldwork. The agroecological properties were approached from the qualitative direction through a literature study, semi- structured interviews with actors familiar with the farming system and field visits. Quantitative data was gathered from previous research results and local administration of agricultural research: yield results, manure application, fodder composition, crop rotations, labour and economic data- preferably data for the year 2012 was gathered.

Diagnosis

The modelling software FarmDESIGN was chosen to evaluate the data presented in Analysis, because it offers a model that adapts a system view of farming systems, thus enabling a complex overview of farm performance (Groot et. al., 2012). The static model of FarmDESIGN was used to calculate flows of energy and nutrients, labour balance and economic performance. Input values for environmental parameters, crop and animal product properties were derived from Groot et. al. 2012 and from default data from the FarmDESIGN software. The static model of FarmDESIGN does not allow for an analysis of SOM dynamics depending on the types and timing of fertilization and management. However, it allows for a static analysis of inputs and outputs that can give an approximation of the effects of crop production on SOM.The dynamic optimization component of FarmDESIGN was used to develop optimization scenarios for the major problems in the farming system identified in the analysis process and reveal synergies and trade- offs between factors. The optimization was run until the optimization clouds showed no more development, between 3 and 5 rounds of 100 iterations.

The diagnosis of the ecological infrastructure management was carried out during the personal visit on printed maps and satellite images, for certain parameters, analysis was carried out on paper, for others, LandscapeLAB was used. The level of which to a landscape that functions well and increases biodiversity can be measured by the percentage of woody elements and the connectivity of non- agricultural components. Land-use, including the presence of woody elements was analysed with LandscapeLab in comparison with surrounding areas. For this comparison, two observation points were designated, one within Krisha- valley and one outside of it and land use was measured within 100, 200, 500 and 1000 meters. The connectivity of landscape elements is a parameter that shows the extent to which landscape components are connected to each other by suitable links as habitats for natural enemies of pests (Hopster & Viser, 2002). Spatial coherence measures the area of interconnected habitat patches in relation to dispersal rates of natural pests (Groot et. al, 2010). Spatial coherence of landscape elements was analyzed with LandscapeLab.

The landscape analysis was based on the landscape analysis theory of different coherences as introduced by Hopster & Visser, 2002. Ecological infrastructure index (EII) provides the percentage of the farm that is managed as a network of ecological infrastructural components. EII was calculated as follows based on Hopster and Visser, 2002:

$$EII = \frac{Agricultural\ area\ managed\ as\ part\ of\ EIM}{Total\ agricultural\ area}$$

In EII calculations, agricultural area managed as part of EIM were sylvicultural areas, tree borders, the area of botanical garden, parks and surface waters.

Width of agricultural fields also influences functional biodiversity and the dispersal capacity of natural enemies of pests. The field size index was (FSI) calculated based on Hopster and Visser, 2002 as follows:

Target: FSI= 0 , no deviation from optimal field size
Calculation: FSI= (A1 (W1-125)/ At) with A1: area of the farm with fields wider than 125 m, W1: average width of fields wider than 125 m and At: total area of farm*
Every 25 units of deviation correspoinds with 10% deficit

To adjudge production yields for cash crops, such as cereals, oil seeds, hay and certain vegetable crops, yields were compared with yield records of Hungarian conventional production and reference yields were estimated for organic production based on scientific resources reviewed by Offerman and Nieberg in 2000. This approach was chosen, because there is no available statistics for organic production yields in Hungary, only anecdotal references are accessible. Since there is no exact data available on the area of different fruit species and varieties and their corresponsive yield records, fruit production was not included in this comparison. Amaranth was also excluded due to unavailability of yield records in Hungary for this crop.

Synthesis

The results of the modelling , the ecological infrastructure analysis and the discussion were used as a basis for understanding how well the agricultural system in Krishna valley complies with the social demands posed towards agriculture. Final conclusions of the farming system analysis and diagnosis was presented in the form of a comparative table, a system model and a SWOT analysis.

3. Results and discussion

3.1. Spiritual and socio- economic context

3.1.1. Spirituality and its social implications

Spirituality refers to the relationship of an individual with a supernatural being, shaping people's perception of the world and their actions. Religions provide a common set of spiritual guidelines and an institutionalization for those. Spiritual guidelines, especially if institutionalized by religion play a central role in defining the worldview of a community and the decisions they make about their daily lives (Var Beek, 2000). If following the interpretation of Pretty on sustainability, sustainable agricultural systems rely on communities and local knowledge (Pretty, 2008). In this context, sustainability will also involve maintaining the quality of life, in which spirituality is of core importance for shaping views and values that individuals or communities hold (Hedlund-de Witt, 2011).

Some alternative social movements (religious or political) demonstrate their disappointment with society not only on the theoretical level, but also on a spatial level by moving away from society. Moving to Krishna- valley is not only driven by religious reasons of individuals, but also by the uncertainties of the "outside world". Founding of Krishna- valley was based on posing an alternative to the individualistic, urbanized and industrialized modern lifestyle by creating a dependable local community. Since Krishna devotees usually move to Krishna- valley alone or with their partners, compared to traditional village societies there is no intergenerational social network, or social homogeneity among members, but a strong coherent social force of the common spiritual values (Gyorgy, 2011). Separation from the rest of society allows for the community to adapt their daily lives to a common set of values, affecting social organization, relationship to nature and shaping the expectations towards agriculture (Seur, 1992).

3.1.2. Krishna- consciousness and spiritual guidelines

The Hare Krishna movement in its modern form was founded in 1966 in New York as the International Society of Krishna Consciousness (ISKCON). Krishna consciousness is a monotheistic form of Hinduism based on ancient Vedic scriptures, Vaishnava philosophy, in more detail on Gaudiya Vaishnavism, the cult of the cowherd Krishna. Krishna is one of the forms (or avatars) of Vishnu, the supreme God of Hinduism. Krishna belief is based on a deep and sincere cultivation of spiritual traditions, a loving and devoting relationship with Krishna to reach fulfilment in the non- material world (ISCKON, 2013; Gyorgy, 2011). The core principles of Krishna- consciousness are as follows:

Krishna
Krishna is perceived as an eternal, omnipresent, omnipotent being who is one with all living things, and therefore all living things are part of Krishna (harekrishnatemple.com, 2013a).

Reincarnation
In all forms of Hinduism living things are not considered as mere bodies, but as souls capable of transmigration. In this understanding, after the death of a certain body the soul is transferred to a different body (Gyorgy, 2011).

Karma
The belief, that every action that is performed in the material world has a reaction. *Vikarma* refers to immoral activities against the laws of nature and is followed by negative effects in the recent life or birth in lower class or in a non-human form after the death of the body. *Akarma* on the other hand refers to all activities that are performed for the pleasure of Krishna and practiced in its highest form lead to entering the non- material, eternal kingdom of Krishna (harekrishnatemple.com, 2013b).

Ahimsa
The aim to stay away from all forms of violence against other living things. *Ahimsa* includes any violence in thought or on the verbal level as well, since these lead to harmful actions and a drawback in spiritual development (krisna.hu, 2013).

Devotional service
All human activities in Krishna- consciousness have to be an offering to Krishna, only in this way can one reach full consciousness and leave the material world behind. Unnecessary accumulation of material goods, activities for one's own enjoyment lead away from spiritual development (Fodor, 2013).

Prasadam
Before eating, all food should be offered to Krishna, this offering is called *prasadam,* which is perceived as free from negative karmic effects and full of spiritual energy (Kurma Dasa, 2005).

These above described principles and all other religious principles described in Vedic scriptures and Hindu epics give very strict guidelines for all aspects of life for a Krishna- devotee. One such central guideline is a strict lactovegetarian diet, since eating meat is considered to be directly connected to violence against other creatures of God (Fodor, 2013). Eating meat, especially cows, is considered to bring *vikarma* not just on individuals, but also on entire cultures (Parta Das, 2013,personal communication, See Appendix… for transcript of interviews). A practical understanding of these principles were explained by Parta Das as follows:

> The basic of Vedic culture is to get led out of the material world, first by little steps, then by larger and larger steps. (…) In the beginning steps you start with the principle of minimal violence, because it is impossible to do no harm at all. But you have to avoid as much violence as possible. It is a lifestyle and a culture to support this deep understanding that every living thing is a living thing. Krishna owns all things and we have to respect this. In the end there is the largest step, to do everything in Krishna's pleasure.

According to Fodor, aggression is also connected to a lack of work- ethic or doing work that one does not enjoy. In order to serve Krishna properly and reach a high level of spirituality, one should have an occupation suited to ones skills and personality, similar to how other living things serve their purpose in nature (Fodor, 2013). Since activities for one's own pleasure, materialism and individualism are considered to lead away from spiritual development, Krishna- devotees are encouraged to lead a materially simple lifestyle and refrain from gambling and any psychotropic substances. As described by Parta Das:

> The way people live in this world, they do not serve Krishna, they try to live like God, they try to control everything. The world is structured in a way that sooner or later we understand that we can try to live like God, but we can never be in his place. (…) We are only going to be happy if we realize this, we are going to be happy if we learn to serve God.

Like every other aspect of life, also the relationship towards nature and agriculture is shaped by Krishna- spirituality. The Sanskrit term *Veda* refers to knowledge, or complete knowledge of the natural laws. The *vedic* worldview builds upon the holistic knowledge of the physical, the living and the spiritual, which can be found in *vedic* scriptures (MVOAI, 2013). The Earth and nature are respected as an ancient mother and always treated with respect (Kun, 2012, pp.40- 50). *Vedic* agriculture is based on a sense of interconnectedness between man, nature and the cosmos and is aimed at enhancing these relationships. Focus is on balancing individual and collective life in a way that it supports natural processes (MVOAI, 2013). In the *vedic* worldview, cows were not tamed from wild animals, but created together with humans. The cow is at the center of *vedic* agriculture, since their urine and manure provide medicine for humans and nourishment for the soil. Krishna himself was a cowherd, which makes cows in Krishna- consciousness holy animals and the relationship between cow and human of central interest (MVOAI, 2013; Ghanasjama Das, 2013, personal communication).

3.1.3. Concepts of self- sufficiency and sustainability

Krishna- valley was founded in 1993 by the Community of Hungarian Krishna Consciousness on an area of 150 hectares with the purpose to develop a self- sufficient farming community in harmony with ancient *Vedic* scriptures and the teachings of the founder of the ISKCON (Kun, 2012). Krisna- valley lies in the village of Somogyvámos, within its administrative boundaries, but on the periphery of the village. In 1993 25 *bhaktas,* or devotees started their life in Krishna- valley. The rural lifestyle enables members of the community to develop a simple lifestyle and maintain a close relationship with God. In this setting, the feeling of being dependent on the gifts of God can be experienced and appreciated every day (Kun, 2012). The motto of the ecovillage is "simple lifestyle, elated thinking", which in practice means a non- materialistic lifestyle, devoted work to support the community and an active practice of spirituality in every day life.

Kun (2012) identifies a self- supporting community which can gain all the goods it requires (through trade or exchange), while he describes a self- sufficient community as one that is capable to produce all the required goods. Self- sufficiency plays a central role in achieving a simple lifestyle, since it enables independency from the outside world and leaves more room open for spiritual development (Radhakanta Das, 2013, personal communication). Self- sufficiency in Krishna- valley is based on ten basic needs of the community. Primary needs of a community include food and water, housing, clothing, healthcare and education. Importance of the other needs varies between geographical location and the aims of the community. These include heating, lighting, transport, handcrafted products, arts and protection of the community. From these needs, food production is identified as the most important one, since sourcing food from external origin requires the most energy (Parta Das, 2013, personal communication). According to Parta Das, as of 2000, Krishna- valley has reached full self- sufficiency in food and around 70% self- sufficiency is firewood.

Since the aim of the community was primarily self- sufficiency and long term sustainability, production for the market was not considered when designing the farming system. It was important to develop a farming system that is adapted to the environment and capable of supporting the community on the long term. Considering economic viability during the designing of the farming system would have shifted the priorities away from self- sufficiency (Kun, 2012).

Self- sufficient farming and production of other goods is paired with the concept of long term sustainability. In Krishna- valley, this means the capability of survival of the community even in case of extreme conditions. Extreme conditions can mean simply a bad year of harvest, but also drastic climate change, natural disasters or war. The aim for the community is therefore is to become as much independent from external inputs as possible (self- sufficiency) and to prepare for unforeseeable conditions. Electricity, running water, gas are not introduced in the community, therefore needs for lighting, heating, water and hygiene need to be met internally.

3.1.4. Organizational and economic structure of the Krishna- valley

Krishna- valley is embedded in the wider community of Krishna- consciousness in Hungary and the world both economically and spiritually. Sivarama Sami, leader of the Krishna- community in Hungary has completed a work on the places of manifestation of Krishna and described 600 holy places within the area. This work has raised Krishna- valley to be one of the central sacral places for Krishna- consciousness in the western world and a place for pilgrimage for devotees from all around the world (Hungarian Community of Krishna- devotees, 2013). Krishna- valley is open to visitors all year round and with religious festivals and other events attracts around 30.000 tourists a year.

Management of Krishna- valley is controlled by a board of directors, from which each member is responsible for one directorate controlling a certain aspect of life. Directors are appointed not by the community, but by the Hungarian Krishna- community, however in itself decision making in the board of directors is of democratic nature. Directorates are composed of departments, which are under the governance of the head of the departments. The heads of departments are appointed by the board of directors. All members of the community are required to provide service in one of the departments, to which they are appointed to by the board of directors according to their skills. Service of the members towards the community is voluntary, but it is compensated by a small amount of money and access to common goods. Although social organization is not of democratic nature in Krishna- valley, *bhaktas* have the opportunity to submit issues or topics of interest to the board of directors through the regular meetings of the departments that they are working for. The hierarchical organization of the directorates and the departments can be seen in Figure 2.

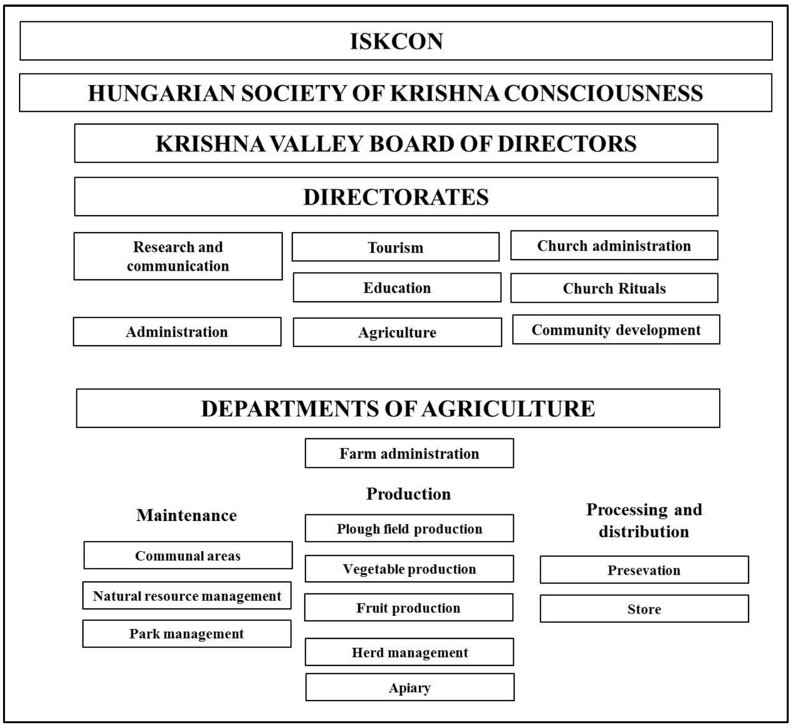


Figure 2. The hierarchal structure of Krisha- valley: Directorates and the departments of agriculture

The economic system is of dual nature, there is a distinction between external and internal trade. External income for the community is generated through tourism, research and education projects, sales of agricultural products and other handcrafted goods and there is also financial support coming from the Hungarian Community of Krishna Consciousness. During the winter season, when farm work is not required, some devotees are selling spiritual books throughout Hungary, also generating some income. Internal trade between the departments and the members of the community is based on a local currency called *sian* Volunteers are partly paid in Hungarian Forints and partly in *sian* to promote internal trade. *Sian* can be spent for goods sold my members of the community or the departments or in the small local shop within Krishna- valley, which sells agricultural products, homemade cleaning and cosmetic supplies and other necessities,

3.1.5. Social life in Krishna- valley

Joining the community requires several years of spiritual preparation. Through different levels the new- joiners are evaluated based on their devotion to Krishna- consciousness and their suitability for the ecovillage- life. Even after joining the community, it takes several years until one becomes a permanent resident. When somebody moves to Krishna- valley, their financial assets are shared with the community for which they are reimbursed should they decide to move away. Several Krishna- devotees live outside of the ecovillage in the village of Somogyvámos, these residents lead a more civilian life, but are usually employed within the ecovillage. The devotees living in Somogyvámos own or rent their own homes and are full- time employees, not volunteers, of the Krishna- community. Besides employment, some village dwellers also run their own enterprises, such as small scale vegetable production or other home production of goods.

Strict religious guidelines affect all aspects of everyday life in Krishna- valley. People start the day around 5 am. with common prayers and meditation in the church followed by common breakfast at the church canteen. Work, or service, as it is described by members, starts at 8 am. and constitutes of seven hours six days a week with one hour lunch break. Lunch is also consumed in the community canteen or at home with family members. Those members who are incapable of working, for example women with small children or the elderly, are supported by the community. After the work day, members gather again in the church for communal prayers and meditation. On Sunday, *bhaktas* spend their day with their families or in different educational or spiritual activities.

Organization of the society is based on the concept on *varnasrama*, the Vedic social structure which is built in a way to enhance spiritual development. In this system four hierarchically organized social casts (*varna*) and four lifestages (*ashrama*) are distinguished. *Brahamasari* are the young devotees until marriage or younger devotees who decided not to marry. *Grihasta* are engaged or married members of the community, this stage is followed by *varnaprasta*, older people with no small children deeply devoted to spiritual life. The highest lifestage is that of *sanasi*, which constitutes of the spiritual leaders and teachers of the community (Fodor, 2013). Members of the community come from a heterogeneous background, and there is no expected level of education for joining the community of filling a certain post. The directorate supports any further education necessary for perfecting ones skills in their work, may it be a couple weeks of training or a university degree.

Marriage in Krishna- valley is organized through a mentor system. If one wishes to get married, they speak to their mentor about plausible partners. Once partners have found each other and announced their wish to get married, a yearlong stage of engagement follows. Only after the wedding can the couple move in together and start a family. Forms of showing physical affection between married couples and sexual activity besides reproduction is discouraged. The mentor system follows also into the years of married life, should there be any issues in the marriage, the couple can consult an older married couple (Fodor, 2013). Children of the devotees are educated in the elementary school of Krishna- valley in the spirit of Krishna- consciousness but in accordance with the Hungarian education system. Older children attend high school outside of Krishna- valley, and are free to leave the community for higher education or to start a life outside of the religious community. Since Krishna- valley is a relatively young community, so far there has been no need to develop a social- care system. As some *bhaktas* turn older and can no longer provide for themselves, a social- care system is under development.

3.1.6. Research and knowledge sharing

The Ecovalley Foundation for Applied Sustainability was founded in 2008 with the aim to demonstrate through personal examples and research result to the wider public how a socially, environmentally and economically sustainable life can be achieved. Ecovalley Foundation cooperates with research institutes, universities and private companies to conduct research in Krishna- valley. Research is aimed at agricultural, environmental and social topics, with the focus on long term sustainability. Ecovalley foundation does not only conduct research, but has a general role in knowledge sharing through their regularly published magazine and organizing workshops and conferences for professionals in the fields of sustainable living (Ökovölgy, 2008c). The functioning of Ecovalley Foundation is supervised by the Hungarian Society of Krishna Consciousness, which decides for appropriate and useful directions of research.

Krishna- valley is also member of the Network of Hungarian Living Villages (Magyar Élőfalu Hálózat- MÉH) which was founded in the early 1990s as a professional and advocacy network for ecovillage initiatives in Hungary. The organization into a network for ecovillages in Hungary allows for sharing of knowledge and experience between the communities on a regular basis (Magyar Élőfalu Hálózat, 2013). Besides knowledge sharing, agricultural products and propagation materials for rare varieties are also exchanged. Directors of the 12 member communities meet twice a year to discuss advancements and common advocacy directions for the network, while the wider public joins together at one of the ecovillages annually. A summary of the socio- economic system can be seen in Figure 3.

3.1.7. Implications of spiritual and socio- economic setting for agriculture

The spiritual and socio- economic context of Krishna- valley strongly affects the expectations of and demands on agricultural production. The interrelations between the spiritual guidelines, the social structure and their implications for agricultural production are summarized in Table 3.

As Krishna is perceived as part of all nature and all nature as part of Krishna, for vedic society this implies a general respect towards nature and all living things and a sense of interconnectedness in a cosmic order between man, nature and God. This approach results in a strong sense of responsibility, or land- stewardship, making the basic guideline in agriculture the understanding of and building on natural processes. The concepts of *Ahimsa* and *Karma* both imply a generally aggression free society of Krishna- devotees. Since any form of violence against an other living thing is unacceptable, Krishna- devotees lead a lacto-vegetarian lifestyle, and therefore agriculture has to serve the needs of such a diet. The "no-harm" mentality is not only valid for animals, but also for nature in general. Since agricultural

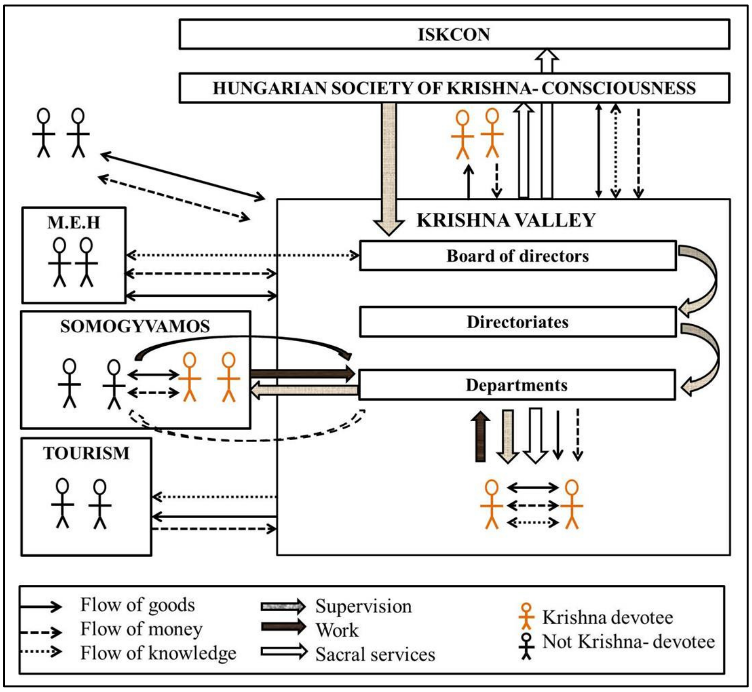


Figure 3. The socio- economic structure of Krishna- valley. Size of arrows does not indicate weight. (ISKCON: International Society of Krishna Consciousness;M.E.H.: Magyar Élőfalu Hálózat (Network of Hungarian Living Villages)

Table 3. Spiritual guidelines and their implications for society and agriculture

Spiritual Guideline	Implications for society	Implications for agriculture
Krishna as a part of all living things and all living things being part of Krishna	Nature and humans as part of a cosmic order, sense of interconnectedness	Understanding and building on natural processes → organic practices
		Land stewardship
Ahimsa (no- harm approach) Karma (action- reaction approach)	Vegetarian lifestyle	Agriculture has to support a lactovegetarian diet
	No forms of aggression are accepted	“No harm” agriculture, avoiding pollution and hurting other living things→ organic practices
	Building up of bad karma in the society will lead to wars and chaos	Agriculture has to support the community on the long- term, independently from external resources
Devotional service	Independence from the outside world	No external resources, aiming for gasoline free production → high reliance on human and animal labor
		Developing local knowledge to adapt to conditions
	Materially simple lifestyle	Agriculture has to support all basic needs, but no luxuries → high diversity of production, for which a high level of specialization is required
	Service suited to the individuals skills, personal development supported	Highly skilled and specialized labor in agriculture, although only if suited members of the community

		have been found
Cow as a holy animal and a companion given to man by God	Cow in the center of the vedic village, all services are accepted	Traction, manure, milk and medicinal products
	Cows can not be killed and as holy animals have to be treated with the highest respect	Herd management has to be based on the whole lifespan of the animals, for which a comfortable life has to be assured

As Krishna is perceived as part of all nature and all nature as part of Krishna, for vedic society this implies a general respect towards nature and all living things and a sense of interconnectedness in a cosmic order between man, nature and God. This approach results in a strong sense of responsibility, or land- stewardship, making the basic guideline in agriculture the understanding of and building on natural processes. The concepts of *Ahimsa* and *Karma* both imply a generally aggression free society of Krishna- devotees. Since any form of violence against an other living thing is unacceptable, Krishna- devotees lead a lacto-vegetarian lifestyle, and therefore agriculture has to serve the needs of such a diet. The "no-harm" mentality is not only valid for animals, but also for nature in general. Since agricultural practices should not harm any other living things, the use of potentially toxic substances such as pesticides and fertilizers must be avoided.

The concept of *Karma* also has some implications for the need of self- sufficiency on the long run. Parta Das (2013, personal communication) explained this as the bad *Karma* building up in the majority of society that will eventually lead to chaos and disorder. In such a case, the Krishna- community has to be able to support its members and the wider Krishna-community. Independence from the outside world is also supported by the devotional service on which the community is based. Devotional service means availability of labor, suited to ones skills but also time for spiritual service. If the community can produce all needed goods for itself, then no extra energy has to be spent on acquiring those goods and more time can be spent on spiritual development. Although devotional service also leads to a materially simple lifestyle, a wide range of needs need to be met within the community, from which food is of primary nature. To meet all the needs of the community in a sustainable matter, agricultural production has to be highly diversified. The aim to make the community independent from external resources implies for agriculture the aim to be gasoline free. Fairly large scale agricultural production in a gasoline free system will have to build on human and animal labor to a large extent. As there are no external sources of water, electricity or gas, besides meeting needs of the community for food, the agroecological system also needs to provide resources for heating, lighting and hygiene.

The cow is in the center of the vedic- village picture as a holy animal and a companion given to men by God, for men and cow to live together is perceived as the most natural form of life. All services of the cows, such as milk, manure, traction and medicine have to be accepted and used. Like other animals, cows can not be killed and as holy animals they have to be treated with the highest respect. In agricultural practice this means, that the herd management has to be based on the whole lifespan of the animals, for which a comfortable life has to be assured. This type of management requires resource- management to plan ahead for 10- 15 years.

The socio- economic structure of Krishna- valley has several implications for agricultural production not directly connected to spirituality. The most central component of the socio- economic structure is the centralized, hierarchically organized decision-making. This allows for a coordinated organization of agricultural production that is suited to the community's needs. The strict rules by which members of the community live are common values shared by everyone. The shared set of common values and acceptance of the centralized leadership makes the community well- organized and adaptable. The development of the size of the community and acceptance of new members is also decided on centrally. In relationship with agriculture, this can ideally mean that agricultural production has to dynamically adapt to the needs of the community and changing conditions. To ensure a stable access to goods, size of the population, the herd, the agricultural area and the level of specialization on labor have to increase in a synchronized manner to ensure long- term sustainability.

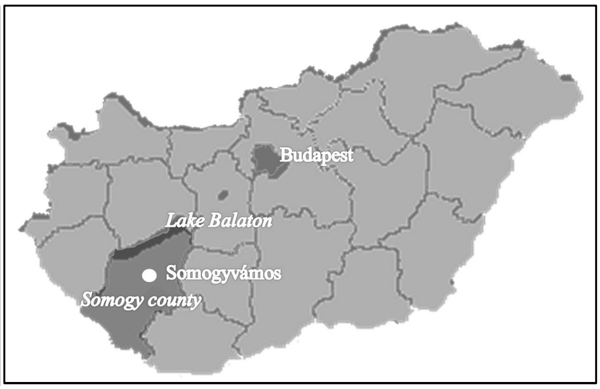
Although the social structure in Krishna- valley is of closed nature, the community is open to the outside world both in an intellectual and an economic sense. Being embedded in a network of ecovillages and sustainability research, Krishna- valley has access to and the possibility of generating of sustainable knowledge and technologies. The stable economic situation (income from tourism, support from the central organization, etc.) allows for room for experimentation in agricultural production. In practice, a partly gasoline- free community can be considered low tech due to the low level of mechanization in production. However, the access to common knowledge and the room for experimentation allows for the agricultural system to dynamically adapt to the expectations and the possibilities.

3.2. Geography, climate and land use history

3.2.1. Demography, geography

Krishna- valley lies in the south- west of Hungary in Somogy- county in the periphery of the village Somogyvámos. The position of Hungary within Europe and its neighbouring countries can be seen in Figure 4.a, while Figure 4.b shows the position of Somogy- county and Somogyvámos within Hungary.

a,



b,

Figure 4.; a, Hungary and its neighboring countries in Europe (Modified after Wikipedia, 2009)
b, Somogy- county and Somogyvámos in Hungary (Modified after Wikipedia, 2007)

Somogy- county lies in the Southern- Transdanubian region closing in on the southern shore of the lake Balaton, the largest lake of Central- Eastern Europe. Out of the 19 counties of Hungary, Somogy belongs to the bottom 50% in terms of GDP (KSH, 2013a). Population in the county is 315.000 with a population density of 52 people/ km^2, making it one of the most poorly populated areas of the country. The population is mostly distributed in small villages with around 1000 inhabitants, although depopulation is striking the region quite heavily and small villages are disappearing yearly (KSH, 2013b). The village of Somogyvámos lies about 25 km south from the lake Balaton and 35 km north of Kaposvár, the capital of the county. Somogyvámos has a population of 826 from which 12% are admittedly Krishna- devotees as of 2011. The village has faced drastic depopulation during the early 1990s, which was also the reason why the major has decided to welcome the Krishna- devotees to the village, hoping new inhabitants and tourist would bring new life to the area (Somogyvámos, 2013).

3.2.2. Climate, geology, landscape

The landscape of Somogy- county is characterized by hills of 150- 300 meters and their valleys with waterways and dwellings. Large number of natural surface waters, mostly rivers and streams are also typical of the region (Tarjánné Tajnafői, 2001). The so called *Nagyberek* used to be an extended area of marshlands southern of the Balaton, which were drained for agricultural production during the 19th and 20th century. Today, some of the *Nagyberek* is conserved as a Natura 2000 area, which excludes Somogyvámos, but includes the neighboring settlements of Somogyvár and Öreglak. The landscape here often still includes true marshlands, although not in their original, connected extension. (Élő Berek, 2013; Kun, 2013). South of the marshlands the landscape changes into one of the most significant sandy regions of the country, typified by a large number of loess structures (Tarjánné Tajnafői, 2001). Somogyvámos lies in the transition zone between the marshlands and the sandy region, its landscape being affected by both (Kun, 2013).

The climate of Somogy is affected both by the hills and the proximity of the Mediterranean sea, resulting in a generally submediterranean climate with alpine influences especially on the northern slopes. Due to the submediterranean effects, the summers are mild and the winters are not extremely cold. Average yearly temperature is 10°C, with a precipitation average of 720 mm yearly, with 50- 60% in the vegetation period, making the area favorable for plants and agricultural production (Tarjánné Tajnafői, 2001). However, in recent years precipitation patterns have shown extremes, sometimes with several weeks of dry periods during the vegetation period followed by an abundance of rainfall or extremely wet summers.(Kun, 2013).

Due to the diversity of conditions on the differently oriented slopes and valleys, there is a diversity of microclimates and habitats in the region. Vegetation in the area is mostly influenced by the mountainous landscape and rivers/ streams in the valleys. The higher hills are typically covered in a natural forest vegetation of silver lime (*Tilia tomentosa*) and common beech (*Fagus sylvatica*), on the lower areas the forest consist of hornbeam (*Carpinus betulus*) and turkey oak (*Quercus cerrus*). In the river valleys, woodland consists of ash (*Fraxinus spp.*) and alder (*Alnus spp.*), while on the clearings riverine humid meadows with a domination of meadow foxtail (*Allopecurus pratensis*) and tall herb vegetation with *Carex spp.* can be found. In the drier valleys, a mosaic of thermophiles forest fringe vegetation with dry grassland is typical (Kun, 2013;Somogy Megyei Múzeumok Főigazgatósága, 2013b; Tarjánné Tajnafői, 2001).

3.2.3. Land use

Traditional land- use in the region was adapted to the diversity of natural resources present. In the valleys of rivers, beef cattle were grazed, in the oak forests pork were matted, while in the drier grasslands sheep were also grazed. Rivers also served as energy source in water mills and were managed for fish production (Somogy Megyei Múzeumok Főigazgatósága, 2013). There are no significant mineral resources in the area, therefore mining was not really present, the industry of the region consisted mainly of glass production from sand and pottery from the loess- clay (Tarjánné Tajnafői, 2001).

In 1091 in Somogyvár, the neighbouring village to Somogyvámos, an abbey of French Saint- Gilles monks was founded by the Hungarian king. The abbey also had considerable lands for plant production and grazing, the monks also bought with themselves technology for wine production. During the Turkish times in the 16th and 17th century, the abbey served as a castle, which was then donated together with the corresponding lands to the archbishop Görgy Széchenyi, which remained in the family until the 20th century. The current lands of Krishna- valley were also in the management of the abbey and later the archbishopric (Tarjánné Tajnafői, 2011).

During the post- war communist era in the 1940-es and 1950-es all private agricultural land was nationalized and forcefully developed into co- operatives. During these times, also in the region of Somogyvámos industrial agricultural started to develop with crops before untypical to the area, such as corn, wheat and fodder beet. During the same time, the extensive cattle breeding became intensive. Up to today, agricultural intensification continues, although since the 1990-es in private agricultural enterprises. In the area, fewer and fewer farmers remain with expanding holding structures (Kun, 2013, personal correspondence). The traditional grazing and sylvicultural production shifted towards agricultural production in the second half on the 20th century on cleared forest areas, which resulted in a high level of erosion of the good quality forest soils and the loess levels coming to surface. As a result of this shift in land- use the forest coverage reduced from 56% in 1784 to 32% in 2011, however, Somogy still remains one of the counties with the most forest coverage in Hungary (KSH, 2013b; Tarjánné Tajnafői, 2001).

3.3. Farming system analysis

3.3.1. History

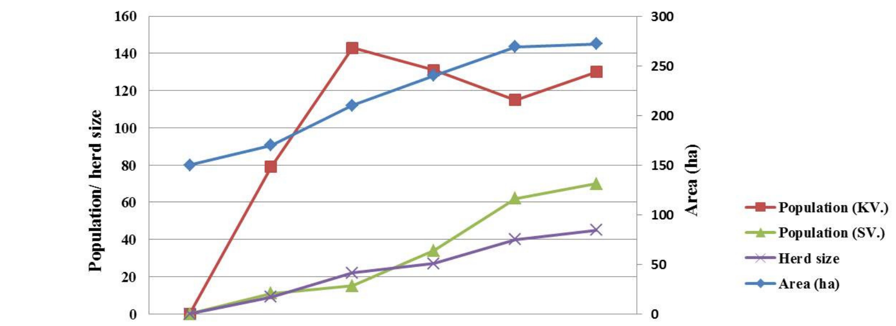
Krishna- valley was founded in 1993 on an area of 150 ha next to the village of Somogyvámos. The area was purchased by the Hungarian Community of Krishna Consciousness with the aim to develop a self- sufficient farming community with a strict spiritual lifestyle, which was described in chapter 3.1. The area of choice from the material point of view had to be a place suitable for agricultural production, a clean environment, a landscape with good qualities and possibly an individual water collection area. Since cows play a central role in *vedic* agriculture, it was important that the area was suitable for animal husbandry. The area had to be suitable for economic sustainability and families with children. During the early 1990-es there was a general rejection towards Krishna- consciousness in Hungary; therefore it was also of central interest that the local residents are accepting towards the new community. The mayor of Somogyvámos saw a good opportunity to develop the depopulating village in cooperation with the Krishna community, and this welcoming attitude played a central role when choosing the final area (Parta Das, 2013, personal communication).

The original area was purchased partly for compensation notes[1] from the Hungarian government and private owners and has been expanded over the last 20 years from 150 to 272 hectares. During the last years however, it has become harder and harder to purchase new agricultural areas- the larger fields have been bought up by expanding neighbouring farms, while smaller fields are hard to purchase due to shared ownership structures (Parta Das, 2013,

[1]Compensation notes were securities issued by the Hungarian government between 1993 and 1994 as a compensation to citizens for nationalizing private property during the communist era. Compensation notes could be used for acquiring new private goods and properties. Secondary trade of compensation notes was enabled to be used for acquiring new private goods and properties. Secondary trade of compensation notes was enabled through the stock- exchange often under face value, which made privatizing national properties to private companies or communities possible for good value (Tarsoly, 2000).

personal communication). Infrastructural development has been continuous since 1993, major milestones in the development were the building of the church in 1996, the elementary school in 2002 and the cow- protection centre in 2006. The houses for the inhabitants are continuously built as the population expands in a residential area.

There is no exact data about the initial population of Krishna- valley, but it is clear that during the last 20 years the population has been showing growing tendency, although not constantly. The population peaked during the early 2000s; setbacks in the following years can be accounted to certain members of the Krishna- community moving out to the village of Somogyvámos, where the Krishna- devotee population has been rising constantly. As of 2013, Krishna- valley has a population of 130 and Somogyvámos has a community of 70 Krishna- devotees, from the community of 200 people there are 80 children. According to Parta Das, the development of Krishna- valley will be continued until a population of 300 *bhaktas* is reached in synchrony with the development of the agricultural production, herd size and firewood production. Figure 5. shows a timeline of the development of the area, population and herd- size of Krishna- valley and Figure 5 shows a map of Krishna- valley with the different land- use types and points of interest.



Year	1993	1998	2002	2007	2012	2013
Area(ha)	150	170	210	240	269	272
Population (KV.)	0	79	143	131	115	130
Population (SV.)	0	11	15	34	62	70
Herd size	0	9	22	27	45	47

Figure 5. Development of the area, population and herd size of Krishna- valley over time. Population KV. stands for the population of Krishna- valley, while population SV. stands for the Krishna- devotee population of Somogyvámos

3.3.1. Agricultural production in Krishna- valley

The components of agricultural production are supervised by the individual departments introduced in Figure 3. in Chapter 3.1.7. The department of farm administration supervises and harmonizes the different production, processing, storage and maintenance activities of the other departments. Production departments include plough- field production, vegetable production, fruit production, herd management, natural resource management and apiary. Maintenance departments are responsible for non- agricultural areas, such as the botanical garden, the parks and the communal areas. Processing and distribution are managed through the departments of vegetable production, preservation and the local village shop. The activity of the departments is not restricted, there is pervasion of labour, by-products and expertise between the different components of agricultural production. All agricultural products are administered by the farm administration, and their destination is decided here as well. Products are consumed fresh (fruits and vegetables), turned into preserves (fruits and vegetables), processed (oils and flours) or stored for security (grains and hay).

The production components are not strictly divided, although there is a certain pattern in their distribution. From the entrance of Krishna- valley, the main road divides the area in two. On the right, forests and the main plough field occupy a hill, on the left, also on a hill lays the cow protection center and larger pastures. The main road leads up to the church, behind which fresh flower and vegetable production occur. The distribution of land- use types were shown in Figure 6., while Figure 7. shows an aerial photograph of Krishna- valley

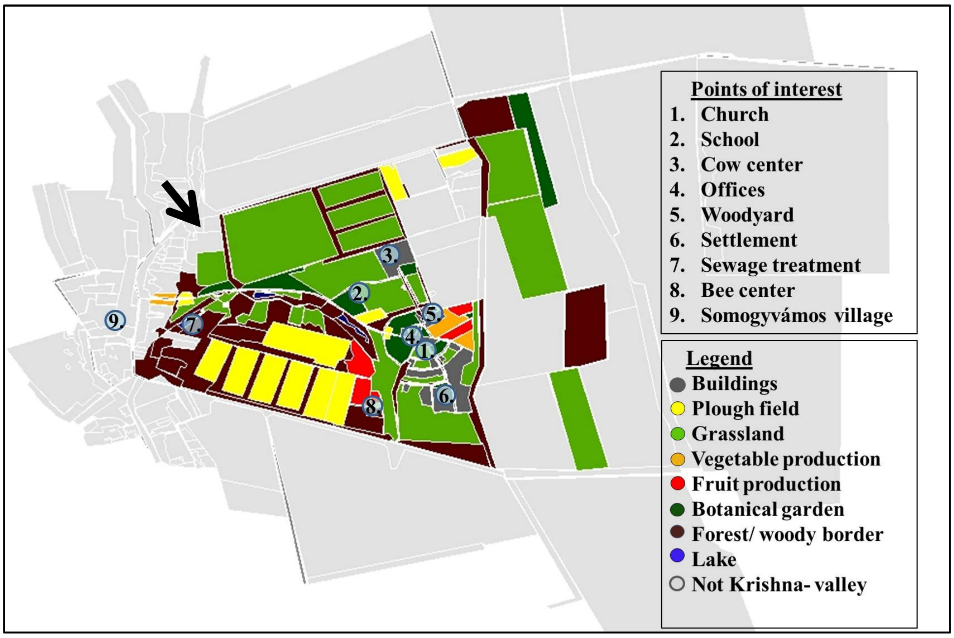


Figure 6. Map of Krishna valley with points of interest and land- use types. The arrow indicates the perspective of the aerial photograph in Figure 7.

Figure 7. Aerial photograph of Krishna- valley, the perspective is indicated in the map of Figure… by an arrow. (Krishna- valley photo repository, 2013, Courtesy of Andras Kun)

3.3.2. Animal Husbandry

As described in Chapter 3.1.7., animal husbandry is in the focus of attention in the agricultural system in Krishna- valley. Cows are holy animals in all forms of Hinduism, therefore they have to be treated with the highest respect and cannot be killed off for their meat. In Krishna- valley, the centre of animal husbandry is therefore referred to as “cow protection centre”, where the animals live until their natural death. Cows are used for their milk, while male offspring is castrated and the oxen are used in plough field production, hay production and transport. Once an animal is too old to give milk or perform labour, they are retired and taken care of until their natural deaths. To financially help the work of the cow protection centre, all animals can be adopted by members of the Hungarian Krishna community in exchange for a financial contribution.

Cattle breeding

The first cow arrived to Krishna- valley in 1996, which was followed by 4 already inseminated cows in 1997; these animals formed the base of the initial herd. During the first years of animal husbandry, population size quickly exploded, resulting in a large amount of milk, but also later a high number of old animals a decade later. To maintain sustainable production, cattle breeding is now planned based on the availability of labor and pastures, in 2013, the herd was composed of 47 animals, from which 4 cows give birth each year. The plan is to develop the herd in a way, that each year 4 cows can give birth, being the active milk producers, and to have 2-3 sets of such groups. In the future, a herd size of 300 animals would be ideal with a larger group of milk producing animals, however, development of the village has to follow in accordance to ensure available work force (Ghanasjama Das, 2013, personal communication).

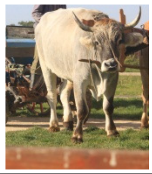
Animal breeding is aimed at developing a multifunctional herd adapted to extensive circumstances, milk production and field work (Ghanasjama Das, 2013, personal communication). The initial herd consisted of the breed *Magyar tarka* (Hungarian Simmental), which is the traditional dual purpose (milk and meat) cattle of Hungary developed during the 20th century (Porter, 1991, pp. 167). The *Magyar tarka,* although a good milk- producer, proved to be unsuitable for oxen labor, due to its sensitivity to sunlight (developing eye- cancer) and their inability to perform labor in warmer conditions (Antardhi Das, 2013, personal communication). The second breed introduced was the *Magyar szürke* (Hungarian grey cattle), which is an ancient breed typical of the Hungarian steppe and well adapted to extensive conditions. The *Magyar szürke* is originally a meat and drought purpose breed; as an extensive cattle breed, milking can be difficult and of low yield. The Indian *Zebu* breed was introduced in the breeding program in 2002 by the arrival of the *Zebu* bull, Nandu. *Zebu* breed is very well adapted to dry climates and is originally a milk and draught purpose breed. There are no pure- breed *Zebus* in Krishna- valley, the bull was bred with the cows from other breeds. The latest breed introduced to the herd was the *Tyrolean Grey*, an alpine breed from Italy and Austria. The *Tyrolean grey* is a three purpose breed, suitable for milk and meat production, draught labor and well adapted to extensive circumstances (Antardhi Das, 2013, personal communication).

Today, breeding is mostly based on external insemination, which enables a selection of genetic lines. In the future, with expansion of the herd, introduction of new bulls and independent cattle breeding is planned (Ghanasjama Das, 2013, personal communication). The current herd shows a very heterogeneous picture, with four different breeds and their cross- overs. The positive and negative attributes of the four breeds are summarized in Table 4, while number and attributions of the different sex and age groups as of 2012 is summarized in Table 5.

Infrastructure

The centre of animal husbandry is the 300 m^2 stable on the north- east corner of Krishna- valley, which was completed in 2006. The stable gives shelter for the cows and their young offspring during the winter, while the bull and the oxen are kept in four outside pens of 500 m^2 and a 280 m^2 semi- covered barn throughout the year. Within the stable, a milk storage facility and a small kitchen for processing can be found. The unmarried *bhaktas* working with the animals have a separate living area above the barn. Besides dairy production, the cow- protection center is also the center of plough- field and grassland production, since a large percentage of field- works is performed with the draught power of oxen. All the machinery required for oxen work is stored at site, so is the hay and the collected manure.

Table 4. The four cattle breeds used in the breeding program of Krishna- valley and their positive and negative attributes

Breed	***Magyar Tarka (Hungarian Simmental)*** 	***Magyar szürke (Hungarian grey)*** 	***Zebu*** 	***Tyrolean grey*** 
Positive attributes	High milk production Strong draught power	Well adapted to extensive keeping Strong draught power	Well adapted to extreme weather conditions	Well adapted to extensive keeping, good milk production and draught power
Negative Attributes	Sensitive to warmth and sunlight	Low milk production Wild nature: hard to work with or milk	Low milk production	
Breeding	Discontinued	Discontinued	Continued	Continued

Dairy production

Milk production is done at a small scale. In 2012 four cows gave birth and were giving a substantial amount of milk. Some of the other cows also give milk, although much less in volume. Altogether in 2012, 50- 60 litres of milk were produced daily, 21900 litres per year. Milking is done by hand twice daily, in the summer months when cows are continuously in the pastures, milking is performed in the open air. Cows with young calves up to the age of 6 months are kept together, although calves are not allowed to suckle any time. The calves are only allowed to suckle twice a day, before their mothers are milked.

Since milk production only serves the Krishna- community, the dairy component is not certified organic unlike the other components of the farm. Most of the milk is used fresh. About 25 liters per day go the church kitchen for preparation of *prasadam* meals, while another 10 liters go to the kitchen of the communal canteen. Some milk (about 35 litres) is collected throughout the week and sent to the Krishna church in Budapest for *prasadam.* Some of the remaining 10- 20 liters of milk is distributed among the elderly and mothers of the community, while another part is processed. Processing the milk is performed in a small kitchen above the barn. Products include ghee (purified butter), cheese and yoghurt, which are sold in the village shop. Since most of the enzymes used for cheese production are of animal origin, cheese production is currently performed with chemical based enzymes. Currently, there is a cooperation with the Agricultural and Food Technology department of Corvinus University to experiment with plant based enzymes. In the meanwhile, Ghanasjama Das, head of milk production is also trying to develop enzyme preparations with traditional plant based enzymes, such as yellow bedstraw (*Gallium verum)*(Ghanasjama Das, 2013, personal communication).

Oxen work

Training the first oxen for labor started in 1997, and by 2013 there were 24 oxen in Krishna- valley, 8 active animals, 10 young ones and 6 retired. The male calves are castrated and given a nose ring before they reach the age one and start their training during the winter of the year they were born. The training takes 2-3 years, the animals work between the ages 3 and 10, after which they are retired and not required to work anymore. Controlling the animals is based on Sanskrit word commands given by the trainer, physical signals with a whip and a rein connected to the nose ring. As mentioned before, training of the animals starts at an early age. According to Antardhi Das, the key to training oxen is regularity and consistence:

> Also what I say sometimes, that even the most well trained oxen will not work nicely if you do not work with them every day. So training is one thing, but regularity is also important.

This means that animals have to be trained regularly around the similar time every day and that every command needs to have only one very clear meaning. Labour is performed with the animals in couples or in multiples of couples (Antardhi Das, 2013, personal communication).

The oxen are paired together usually permanently based on their strength, temperament and abilities. Generally, all agricultural field work can be performed with the oxen, just a lot slower than with machines (see Chapter 3.3.3. for labor hours). The main tasks performed with the oxen are 1) Freight transportation 2) Plough field works 3) Making hay 4) Capstan 5) Personal transportation and participation in parades. For freight transportation the general rule of thumb is that each animal can carry the double of its own weight under good road conditions (dry and no slope), which is dramatically reduced should the road be uphill or muddy. Basically all freight transportation in Krishna- valley is performed by the oxen, such as the collection of harvested plough field products, hay and firewood (Antardhi Das, 2013).

Plough field management with the oxen is performed with agricultural machines altered by a locksmith to fit the oxen carriages. All basic soil works that can be performed with a tractor can also be performed with the oxen. These include 1) Turning with a plough 2) Mixing with disks 3) Levelling with a harrow 4) Loosening with different cultivators 5) Compressing with a roller 6) Seeding 7) Harvesting. The system for the field works with the oxen is not fully developed yet and currently is only complementing field work with the tractor. The development of the machines is aimed at reaching higher horsepower requirements but multiple functions, such as a spring harrow connected with a clot breaker. This way less man-power is needed for fieldworks and also time can be saved for gearing up the animals. Detailed quantitative data about the oxen and human labor for plough field management will be presented in Chapter 3.3.3. While oxen work for plough field production is only complementary to mechanized management, hay production is completely dependent on animal power. Hay production includes cutting, turning and collecting the hay from the grasslands and lucerne fields. Like with plough field management, the hay production is also dependent on altered agricultural machines (Antardhi Das, 2013, personal communication).

Feed and pasture management

Feeding the herd is completely dependent on grazing and farm produced fodder. Grazing the animals occurs on the pastures around the cow protection center and some outer fields. The grazing period lasts approximately 180 days during the summer, during which the animals spend all their time on the pastures. If the weather allows for it, animals are allowed to spend time outside even during the autumn/ winter period. Some fields are utilized only for grazing, some only for cutting, while some are mixed; the use depends on the quality of the grass and the soil in the current year. To prevent long term compaction by trampling, pastures are broken up every 10 years and reseeded with a commercial grass mixture (Antardhi Das, 2013). Breaking up the pastures takes them out from grazing or cutting for 1 year, and it is considered as hindering the development of beneficial herbaceous vegetation, therefor the management is considering switching to permanent pasture management (Ghanasjama Das, 2013). Hay production from the alfalfa fields is included in the plough- field management and rotations, while all other grassland production is managed separately. Grassland areas and management will be discussed in Chapter 3.3.3.

Hay is produced from grass mixtures from the pastures and from alfalfa fields, in 2012 approximately 100 tons of hay was produced. Hay production does not only cover the needs of the animals for the winter of the current year, it is also stored in quantities enough for 1-1,5 years, should there be any problems in agricultural production (Radhakanta Das, 2013, personal communication). According to Antardhi Das, on average an adult animal consumes 2,5 tons of hay during the winter months, milking cows and old animals are also provided hay during the summer and concentrate throughout the year. The concentrate ideally consists of 2 units barley grain, 1 unit wheat grain and 1 unit oats, in 2012 however the concentrate consisted of 3 units barley grain and 2 units oat grains. Altogether, the working, milking and old animals consume about 3,5 tons of concentrate annually. (Antardhi Das, email correspondence).

Detailed description of the feed requirements of the animals can be found in Table 5a.) and the requirements of the herd are summarized in Table 5b.)

Table 5. (a) Bedding, forage and labor requirements per animal type (b) Total annual bedding and forage requirements of the herd. Quantities provided in fresh matter kilograms (FM) and dry matter kilograms (DM)

a,

Animal type	**Number**	**Average age (years)**	**Average weight (kg)**	**Bedding (kg/animal/year) FM *(DM)***	**Hay (kg/animal/year) FM *(DM)***	**Fodder (kg/animal/ year) FM *(DM)***	**Labor (hours/animal/year)**
Ox (calf)	2	0,5	175	446*(402)*	667 *(600)*	0	200
Ox (young)	2	2	600	1054*(949)*	1667*(1500)*	0	200
Ox (active)	10	7,5	900	1054*(949)*	2111 *(1900)*	220 *(194)*	200
Ox (retired)	10	14	900	1054*(949)*	2111*(1900)*	220 *(194)*	200
Bull	1	14	1000	1054*(949)*	2111*(1900)*	0	200
Cow (calf)	2	0,5	150	446*(402)*	667*(600)*	0	270
Cow (heifer)	2	2	475	446*(402)*	1667 *(1500)*	0	200
Cow (milking)	4	7,5	700	446*(402)*	4172 *(3755)*	220 *(194)*	340
Cow (non- milking)	5	7,5	700	446*(402)*	2000 *(1800)*	0	300
Cow (retired)	7	14	700	446*(402)*	2000 *(1800)*	220 *(194)*	200

b,

Product	**Provided during the grazing period (kg/ 180 days) FM *(DM)***	**Provided during the stable period (kg/ 200 days) FM *(DM)***	**Total amount provided (kg/year) FM *(DM)***
Bedding	0	34000 *(30660)*	34000 *(30660)*
Hay	8689 *(7820)*	85667 *(77100)*	94356 *(84920)*
Forage	1708*(1503)*	1708*(1503)*	3417*(1503)*

Comfort and care

The 300 m^2 barn was planned to provide housing for 40 animals and is currently not functioning at full capacity. The barn structure is composed of open stalls with a deep litter system and access to outside yards. The structure of the barn also allows for keeping calves and mothers close to each other, but since all animals are tied up during time spent in the barn, calves are not allowed to suckle freely. While the barn of the cows is completely closed and protected, the pens for the oxen and the bull is of more open nature with semi closed barns for protection. In the barn and in the yards, straw from the cereal production is used as a bedding material provided during 200 days of the non- grazing period. While the barn requires around 50 kg bedding per day, the yards have a higher requirement of 100 kg/ day during the 200 days long winter period. Since the animals do not spend considerable amount of time in the yard and the barn during the grazing period, no bedding is provided in the summer. Bedding requirements in total and per animal type are summarized in Table 6.

Healthcare of the animals is mostly based on *ayurvedic* medicine, plant based tinctures that enhance the general health and milk production. In case of more serious illnesses, antibiotic treatment is possible, although in recent years there was no need for these. A drastic preventive action had to be taken in 2001 when a foot and mouth disease epidemic was affecting cattle all over Hungary. Since Krishna valley was expecting 30.000 visitors for a festival that year, which carried the risk of incoming infection, the herd of 20 animals and 3 caretakers have spent several weeks in the externally lying pastures and forests. This avoidance of contact with possible infections helped to prevent an outbreak of foot and mouth disease (Antardhi Das, 2013).

Manure

Manure from the barn is collected in autumn and during winter months and from the oxen yards once a year. Fresh manure is ripened in piles at the barn site for distribution in Krishna- valley and sales; or at the plough fields for later use in 1,5* 1,5 meter piles. Yearly, 250 tons of manure is collected and distributed among vegetables production, plough field production and family garden production.

Labor

Given the important spiritual role the cows play in Krishna- valley, only devotees are allowed to work with and around them. Three *bhaktas* take care of the cows, four *bhaktas* are working with the oxen and there is one head of department managing animal husbandry. The four oxen caretakers also substantially contribute to plough field production, since they are the ones training and controlling the animals during field works. The *bhaktas* in animal husbandry work 6 days a week, 7 hours per day throughout the year, except for certain weeks in the winter when young *bhaktas* are performing missionary service in larger cities (Antardhi Das, email correspondence). Labour hours per animal type are provided in Table 5. Year long, the labour spent managing the herd equals to 5000 hours. The distribution of the oxen caretakers and the animals' labour hours among different tasks is presented in Table 6. Year round, the oxen put in 4536 hours of labour, partly in plough field and grassland management, partly in transportation and the time spent during gearing up the animals.

Table 6. Summary of different tasks and their corresponsive human and oxen labor hours

Task	Labor type	Labor hours/ year
Herd management	Human	5000
Plough field and grassland management	Human	1300
	Oxen	2736
Transport & gearing up	Human	900
	Oxen	1800
Farm management	Human	800
Total	Human	8000
	Oxen	4536

3.3.3. Plough field and grassland production

Plough field production provides the community with cereals and legumes and allows for externally marketable products, such as mustard seeds and certain cereals. Production is supervised by the director of agriculture, Radhakanta Das in strong cooperation with the oxen component for providing labor for fieldwork. In 2012, 29 hectares were in plough field production with 9 different crops. Plough field production is organically certified that adds value to the products that are sold outside of Krishna- valley.

Crop and variety selection

The main purpose of plough field production are providing cereals covering the needs of self- sufficiency of the community and the herd, besides which a certain amount of production for the market also takes place. During the variety selection and the design of the crop rotations an important aspect was also to minimize work- load that has to be spent on crop care. This resulted in large areas of cereal and oil crops and no or very low production of row cultures, such as corn or sunflower, which are excluded from large scale production due to high labor intensity (Barsi, 2012; Radhakanta Das, 2013).

The main crops in plough field production are alfalfa and winter wheat, grown on 10,25 hectareas and 7,7 hectares respectively. The production of winter wheat does not only cover the needs of the community, but also allows for income generation through sales. In recent years, there were several experiments with heirloom Hungarian varieties of wheat, such as *Bánkúti* and *Jubilejna* and more ancient varieties, such as spelt and emmer. Although the last two need to be hulled, thus require more labor time before milling, the mill in Somogyvámos can perform such a task. Experiments were carried out with buckwheat, but in three consecutive years the crop has failed and production was discontinued. Successful experiments include millet, amaranth and chickpeas, which are still grown in certain years. Mustard is grown as an oil crop that is sold, but also as a green manure crop. Another dual purpose crop is phacelia, which is used as a green manure, but also serves as a bee pasture.

Traditional varieties acquired from seed banks in low amounts which are then multiplied for large scale production should they be suitable. Cereal seeds are saved in consecutive years for reseeding and refreshed every 4-5 years by purchasing new seeds to avoid genetic deterioration.

Rotations

Each year, the crop rotations are planned based on needs and labor capacity of the community, although there is a distinct 6 component and a 3 component rotation. Crop areas in total and for different rotations are presented in Figure 7. The largest constituent of plough field production is the 6 component crop rotation lying above the valley (see the yellow fields in Figure 6.). The rotation is composed of nutrient building crops, cereals and oil crops, the concrete sequence is alfalfa, oats and barley, alfalfa, wheat, mustard with phacelia and wheat. Each field in this rotation has similar size, between 2,5 and 3 hectares, although one field is split in half for oat and barley production. The rotation can be altered each year so that the production capacity meets the needs of the community. The 3 component rotation in 2012 included wheat, mustard and sudan grass with field sizes ranging from 2,2 to 2,7 heactaers. Amaranth and sunflower are grown on a smaller scale outside of the two major rotations, sharing fields with vegetable production.

Grassland production is managed apart from plough field production and has its own rotation. Grassland fields differ in their uses, some fields are utilized solely as pastures for grazing, some only for cutting for hay, some are mixed purpose. Since pastures are broken up every 10 years, part of the grassland rotation each year is also a newly seeded pasture.

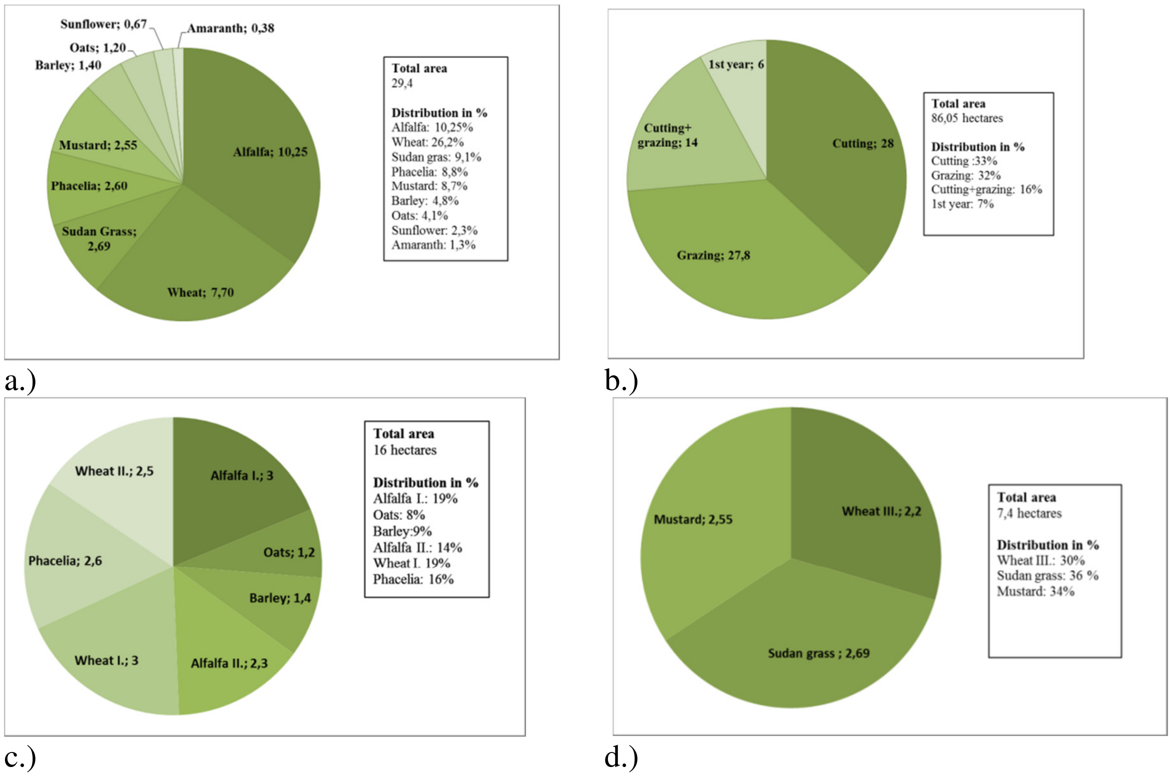


Figure 7. Crop and area distributions of plough field and grassland crop rotations. (a.) Total plough field production, (b.) Total grassland production, (c.). Plough field rotation I.,(d.) Plough field rotation II.

Crop management

It is a general aim in crop management to minimize reliance on external inputs, including gasoline for the tractor. All field works that can be carried out with the tractor can also be carried out with oxen power, the limiting factor in this case is the availability of labour and oxen power. Especially plough field soil works and harvesting in the autumn conflict with the peak time of harvesting grass for hay, which reduces the availability of labour during this season. It is for this reason that all harvesting work for cereals, oil crops and working green manure in to the soil is performed with the tractor, while ploughing and other soil works are carried out with oxen power as much as labour availability allows for it. In 2012, 6 hectares were ploughed with oxen, while the remaining 23 hectares of plough land production were ploughed with the tractor. Soil works in plough field production include ploughing, mixing, levelling, loosening and compressing. There is no exact data however on the timing and performance (tractor or oxen) of these tasks, but labour requirements and estimated labour hours will be discussed in the following labour chapter.

Seeding is performed by hand for spelt, grasses and alfalfa and with the oxen for all other crops. The seeding machine currently used with the oxen is an Isaria type nodular machine where the seeding is driven by the movement of gears. A special mechanism within the seeding machine allows for setting the seeding density independent of the speed of the animals pulling it.

Providing nutrients to the crops relies solely on leguminous nitrogen fixation, animal manure and green manure crops, no artificial fertilizers are used. Both the 6 and the 3 component rotation include alfalfa, providing nitrogen and organic matter to the soil and the following crops, other green manure crops, such as mustard, phacelia and sudan grass are also incorporated in the rotation. Animal manure is used exclusively for the wheat that does not follow alfalfa in the crop rotation, these 2,5 hectares receive 30 tons of farm yard manure per year.

The heavy clay soils are prone to compaction, which is reduced by not tampering with the fields when they are too dry or too muddy. Alfalfa not only plays a role in providing nitrogen, but with its deep roots helps to reduce soil compaction caused by plough pen. To prevent erosion on the hilly slopes, tree rows were planted parallel with the slope direction as windbreakers and following all soil works the soil is closed up to reduce the exposed surface. Crop residues are not systematically left on the fields, only when the rotation allows for this, for example when autumn harvest is only followed by seeding in the spring.

In recent years, cereal leaf beetle was the only pest problem present, but even this did not reach the levels of serious infestation. Pest and weed management relies solely on rotation design and resistant varieties. In the plough field and grassland management, there is no irrigation used. To avoid yield loss from drought, drought resistant varieties, such as emmer and spelt are used.

Labour

Crop areas that provide for the needs of the community are at all times worked with animals only, while crop areas providing marketable production are worked partly with the tractor and partly with the oxen. As mentioned before, 6 hectares of wheat are ploughed with the oxen, while the remaining 24 hectares are ploughed with the tractor. Other field works can also be provided with the oxen, although there is no exact data about which fields were worked and which tasks exactly were carried out by the oxen. Data is available however for how much time different tasks take with the alternative methods, which are summarized in Table 7. A basic calculation method for the time requirement for the different field works is based on the size of the machine and the speed of the oxen. The oxen pull machines with 2,5-3 km/ hour, so multiplying 2500- 3000 with the width of the machine in meters can provide the size of the area that can be worked in an hour. For the calculations in Table 7., a medium speed of 2.75 km/ hours was used. While there is exact data about labour used for ploughing in 2012, other field works were only estimated based on the provided data about oxen hours used during the year. Data and estimates about yearly labour requirements for the plough field production are provided in Table 8.

Table 7. Tasks and alternative management methods for plough field and grassland management, labor and oxen hours. (Labor and oxen hours in italics refer to labor requirements expressed in hours/ ton.)

Task	**Machine/ tool**	**Crops**	**Method**	**Number of workers**	**Number of oxen**	**Hours/ha (*hours/ton*)**	**Labor hours/ha (*hour/ton*)**	**Oxen hours/ha (*hours/ton*)**
Turning Working in green manure	Plough	All, except perennial grassland	Tractor	1	0	2	2	0
			Oxen	1	6	18	18	108
Mixing	Disk	All, except perennial grassland	Tractor	1	0	1	1	0
			Oxen	1	4	3	3	12
Loosening	Cultivator	All, except perennial grassland	Tractor	1	0	1	1	0
			Oxen	1	4	3	3	12
Compacting	Roller	All, except perennial grassland	Tractor	1	0	1	1	0
			Oxen	1	4	1	1	4
Sowing	Seed drill	Cereals, oil seed crops	Oxen	1	4	3	3	12
	By hand	Grasses, alfalfa and spelt	By hand	1	0	1	1	0

Harvesting	Harvester	Cereals, oil crops	Tractor	1	0	2	2	0
		Cereals, sunflower, amaranth	Oxen (hand shiefing)	22	4	4	88	16
		Cereals	Oxen (mechanical shiefing)	2	4	4	8	16
Cutting	Scythe	Grass, alfalfa	Tractor	1	0	1	1	0
			Oxen	1	2	2,5	2,5	5
Turning	Fork	Grass, alfalfa	Turning by hand	1	2	1,5	2,5	5
Rolling	Fork	Grass, alfalfa	Rolling by hand	1	2	2,5	2,5	5
Collecting	Cart	Grass, alfalfa	Loading to oxen driven cart	3	2	*5*	*15*	*10*
	Hay loader	Grass, alfalfa	Loading to oxen driven hay loader	5	6	*1,4*	*7*	*8,4*
	Oxen driven hay baler	Grass, alfalfa	Oxen pulled hay baler	3	8	*1,4*	*4,2*	*11,2*

Ploughing is performed with a single blade plough that manages 20 cm width. Due to the small width of the plough, ploughing is the slowest and thus most labour intensive soil work, requiring 6 oxen and 18 hours/ ha. In comparison, this area can be ploughed with the tractor in around 2 hours. All other field works, such as mixing, loosening, compacting and seeding takes significantly less time with the oxen than ploughing, between 1-3 hours/ hectare with 4 oxen and 1 person. In the labour calculations, field works besides ploughing were taken to be carried out with the oxen.

Seeding of all cereals and oil crops (except spelt) is carried out with a seed drill pulled by 4 oxen. This task takes 3 hours/ hectare for one person. Seeding spelt and grasses by hand allows for one person to sow a 9 m wide area while walking forwards. Estimating a speed of 1 km/ hour, one person can seed approximately 1 hectare in one hour.

Table 8. Labor tasks, methods, labor and oxen hours for field works, seeding and harvest in plough field production

Crop	**Area (ha)**	**Tasks and methods**	**Labor (hour/ha)**	**Oxen (hour/ha)**	**Labor hours total**	**Oxen hours total**
Amaranth	0,38	Ploughing with tractor, field works with oxen, sawing with oxen, harvesting by hand	34	132	13	50
Barley	1,4	Ploughing with tractor, field works with oxen, sawing with oxen, harvesting with tractor	14	44	20	62
Mustard	2,55	Ploughing with tractor, field works with oxen, sawing with oxen, harvesting with tractor	14	44	36	112
Oats	1,2	Ploughing with tractor, field works with oxen, sawing with oxen, harvesting with tractor	14	44	17	53
Phacelia	2,6	Ploughing with tractor, field works with oxen, sawing with oxen, working in with tractor	14	44	36	114
Sudan grass	2,69	Ploughing with tractor, field works with oxen, sawing with oxen, working in with tractor	14	44	38	118
Sunflower	0,67	Ploughing with tractor, field works with oxen, sawing with oxen, harvesting by hand	34	132	23	88
Wheat I.	3	Ploughing with oxen, field works with oxen, sawing with oxen, harvesting with tractor	31	152	93	456
Wheat II.	2,5	Ploughing with oxen, field works with oxen, sawing with oxen, harvesting with tractor	31	152	78	380
Wheat III.	2,2	Ploughing with tractor, field works with oxen, sawing with oxen, harvesting with tractor	14	44	31	97

Currently, harvesting of all cereal and oil crops is performed with the harvester, because of the extreme high labour requirement of harvesting cereals by hand. An area of 1,5-2 hectares can be harvested by 20 people in one day (8 hours), following an oxen cart where 2 people cut the wheat and put them in sheafs which need to be tied up by the others. With a special harvester it would be possible to sheaf and tie up the cereals at the same time, saving the labour hours of 20 people, however, this machine is currently not available in Krishna-valley. Only sunflower and amaranth are harvested by hand, but there is no available data on the labour requirement for this task. In the calculations, labour requirements for harvesting cereals were used for sunflower and amaranth.

Cutting, turning and rolling grass and alfalfa for hay is performed with oxen driven machines driven and operated by one person. These tasks can be carried out with 2 oxen. The most labour intensive task of hay production is collecting the dried hay, which can be carried out with three different methods. The three methods differ among the type and capacity of the cart used for collecting and the number of labourers and oxen required to carry out the collection. Capacity of the carts ranges between 1-5 tons, require 2- 5 workers for loading and 2-8 oxen for transport. Labour requirements for the grassland production also depend on the number of cuttings/ year. According to information gathered from Krishna- valley, each field is cut 2- 5 times each year, producing 2-3 tons of hay per cutting. This information however is in discrepancy with the yield records that show 2-3 tons of hay production per hectare in total annually. When calculating labour hours for hay production, an estimated 1 ton/ ha/ cutting production and the method of hay loader was used. Results for labour requirements for grassland production are provided in Table 9.

Crop products: Storage, processing and distribution

Crop products from plough field production include cereals, oil seeds, hay, straw and green manure. After harvesting, cereal and oil crop seeds are freed from weed seeds and dust with a wind separator that blows the seeds through different sized sieves. Seeds are husked mechanically if necessary. Storage occurs in large textile bags of 800 kg after drying the cereals on the floor for 2-3 weeks. Since each year a security storage is created, of about 1/3 of the yearly cereal need of the community, grain storages are not empty by the next harvest. Cereals are stored for up to three years, after which time they are usually fed to the animals or sold.

Processing cereals into flour is carried out by the oxen- caretakers in the village mill in Somogyvámos, or by the families at home with small capacity hand mills. Amaranth is popped over low heat and used as an enricher to flour. Oil from sunflower seeds and mustard seeds is pressed in Krishna- valley. In the future, processing of both cereals and oil seeds is planned to be carried out with the oxen drive capstan, which requires further technical development to carry out these tasks. Oil is not only used for cooking, but also for lighting in the electricity free residential houses.

Products from the plough field production are distributed to the church canteen or to the inhabitants through the village shop, directly distributed to the animal husbandry component or sold. The allotment of crop distribution is summarized in Table 11. The products for external sales include mustard (100%), wheat (80%) and hay from alfalfa (30%). Oats, barley and the remaining hay from alfalfa are exclusively used as fodder for the animals, whereas straw for bedding comes from cereals. Crops produced in lower quantities, such as amaranth and sunflower are only distributed within the community.

Table 9. Labour tasks, methods, labour and oxen hours for field works, cutting and collecting hay in grassland production

Crop name	Area (ha)	Tasks and methods	FM yield/ha	FM yield total	Number of cuttings/year	Labor hours field works	Labor hours cutting	Labor hours collecting	Oxen hours field works	Oxen hours cutting	Oxen hours collecting	Labor hours/ha	Oxen hours/ha	Total labor hours	Total oxen hours
Alfalfa I.	3	Ploughing with tractor, field works with oxen, seeding by hand, cutting, turning, rolling with oxen, collection with hay loader	3100	9300	3	24	59	13	96	39	52	32	62	96	187
Alfalfa II. (2nd year)	2,3	Cutting, turning, rolling with oxen, collection with hay loader, working in green manure with tractor	4600	10580	4	1	60	15	0	52	59	33	48	76	111
Alfalfa III.	4,95	Ploughing with tractor, field works with oxen, seeding by hand cutting, turning, rolling with oxen, collection with hay loader	3100	15345	3	40	97	21	158	39	86	32	57	158	283
Grass (cutting)	28	Cutting, turning, rolling with oxen, collection with hay loader	2000	56000	2	0	364	78	0	26	314	16	12	442	340
Grass (cutting+ grazing)	14	Cutting, turning, rolling with oxen, collection with hay loader	1000	14000	1	0	91	20	0	13	78	8	7	111	91
Grass (grazing)	27,8	None			0	0	0	0	0	0	0	0	0	0	0
Grass (1st year)	6	Ploughing with tractor, field works with oxen, seeding by hand	0	0	0	48	0	0	192	0	0	8	32	48	192

Table 10. Crop areas, crop products and destination of crop products in plough field and grassland production. FM indicated fresh matter kilograms, DM indicates dry matter kilograms.

								Destination (kg DM)									
Crop name	**Area (ha)**	**Crop product**	**Fresh yield (kg/ha)**	**DM content**	**DM yield (kg/ha)**	**Fresh yield total (kg)**	**DM yield total (kg)**	**Home use/ Church kitchen**	**%**	**Green manure**	**%**	**Fodder**	**%**	**Bedding**	**%**	**Sales**	**%**
Alfalfa	10,25	Hay	3437	0,90	3093	35225	31703	0	0%	0	0%	22181	70%	0	0%	9522	30%
		Green manure	9900	0,20	1980	78705	15741	0	0%	15741	100%	0	0%	0	0%	0	0%
Wheat	7,7	Wheat	3000	0,87	2610	23100	20097	3970	20%	0	0%	0	0%	0	0%	16137	80%
		Straw	4500	0,90	4050	34650	31185	0	0	8910	29%	0	0	22275	71%	0	0%
Sudan grass	2,69	Green manure	1000	0,16	160	2690	430	0	0%	430	100%	0	0%	0	0%	0	0%
Phacelia	2,6	Green manure	1000	0,17	170	2600	442	0	0%	442	100%	0	0%	0	0%	0	0%
Mustard	2,55	Mustard seed	800	0,94	752	2040	1918	0	0%	0	0%	0	0%	0	0%	1918	100%
Fruit	2,1	Fruit	2950	0,2	590	6195	1239	1239	100%	0	0%	0	0%	0	0%	0	0%
Barley	1,4	Barley	3000	0,87	2610	4200	3654	0	0%	0	0%	3654	100%	0	0%	0	0%
		Straw	4000	0,9	3600	5600	5040	0	0%	0	0%	0	0%	5040	100%	0	0%
Oats	1,2	Oats	2200	0,89	1958	2640	2350	0	0%	0	0%	2350	100%	0	0%	0	0%
		Straw	4000	0,9	3600	4800	4320	0	0%	0	0%	0	0%	4320	100%	0	0%
Sunflower	0,67	Sunflower seeds	1490	0,92	1371	998,3	918	918	100%	0	0%	0	0%	0	0%	0	0%
Amaranth	0,38	Amaranth	260	0,89	231	98,8	88	88	100%	0	0%	0	0%	0	0%	0	0%
Grassland (cutting)	28	Hay	2000	0,9	1800	56000	50400	0	0%	0	0%	45400	81%	0	0%	5000	19%
Grassland (cutting+ grazing)	14	Hay	1000	0,9	900	12600	11340	0	0%	0	0%	12600	100%	0	0%	0	0%
		Grass	10000	0,2	2000	140000	28000	0	0%	0	0%	28000	100%	0	0%	0	0%
Grassland (grazing)	27,8	Grass	10000	0,2	2000	278000	55600	0	0%	12831	57%	42769	43%	0	0%	0	0%
Grassland (1st year)	6	Grass	10000	0,2	2000	60000	1200	0	0%	12000	100%	0	0%	0	0%	0	0%

3.3.4. Vegetable production

Crop and variety selection

Crop variety in the vegetable production serves the purpose to enable a continuous and diverse supply of vegetables to the church canteen and the inhabitants of the Krishna- village. In 2013, there were 40 different vegetable species and numerous varieties of these cultivated. Variety selection is based on experience, and varieties that have been performing well over the years are reused. The aim is to have continuous availability and varieties well adapted to local conditions and to use non- hybrid varieties to enable seed saving. In the recent years of vegetable production, heirloom varieties proved to be more adaptable to local conditions, therefor only these are cultivated. There are certain species that perform very well under the conditions in Krishna- valley, such as the zucchini, which allows for a wide selection of types, colors and growing period. Experimenting with the varieties is easier for vegetables with short growing periods, while finding the right variety for long growing season plants takes several years. It is common practice that for each vegetable species there is one variety grown in larger quantities for preservation and storage and several others for fresh consummation throughout the season.

The vegetable production has to adapt to the dietary habits of the Krishna religion, therefore species traditionally used in Indian cuisine, such as the karela and sweet potato were also introduced to production. Although members of the *Solenacea* family, such as the tomato or the aubergine are considered to have bad effects in vedic culture, due to the climate these are grown in large quantities as well. Species that cannot be consumed by Krishna- devotees, such as onions or garlic are only grown for companion planting or to make preparations to use in production of other species. Vegetable production is substituted with foraging wild plants in the area, although only in low quantities.

Seed saving and management

To achieve self- sufficiency to the highest degree possible, seed saving is an important practice in vegetable production in Krishna- valley. It is a general pursuit to produce only varieties that can be propagated, thus no hybrid varieties are in production. Seeds for heirloom and specialty varieties are acquired from the United States through the internet, from Hungarian seed banks and through exchange from other ecovillages and organic farmers.

Seed production for cross- pollinating plants has to take into consideration pollination distances. These plants are pollinated by hand and covered with a net to protect from cross- fertilization. Each year, the best specimens of each variety are designated for seed production. The seeds are collected by hand and then dried in the heated greenhouse. It is important to keep a tight administration about the saved seeds, due to varying extent of germination capacity and storage requirements. Even if the variety is not grown in large scale that year, it is planted for seed production to maintain germination capacity.

Infrastructure

Vegetable production relies to a large extent on the built infrastructure to optimize growing conditions and extend the growing season. Currently, there are two 200 m^2 foil greenhouses, one 400 m^2 glass greenhouse and a heatable 10 m^2 warmhouse used in production and processing. The foil greenhouses serve early spring and autumn production of leafy greens and strawberries, while the glass greenhouse allows for summer production of warmth requiring plants, such as the karela and cucumbers. During the winter months, the glass green house allows for growing winter leafy greens and herbs by protecting from the wind and providing extra warmth- around 3 to 5 °C compared to the outside temperature. The small glass greenhouse is heatable with a wood fired oven and a chimney that extends through the building. This greenhouse is used in the spring for starting seedlings in optimal conditions and during the autumn to dry seeds for the seed bank.

An other important infrastructural component of the vegetable and the fruit production is a three tunneled, 300 m^2 cellar for storage of fresh and processed produce. Besides this brick facility, there are smaller earth- dug pit holes covered with wooden roofs. The cellar is also the site of the local market, where sales of the fresh products takes place to the inhabitants of Krishna- valley.

Irrigation in the vegetable garden is served by a drip irrigation system. While the drip irrigation system sources water from a well, there is also a rainforest collecting facility constituting of three 1 hectoliter capacity barrels collecting rainwater from the glass greenhouses. This water is used for watering plants by hand in the greenhouses.

Crop production

Vegetable production in Krishna- valley has two main components, a summer garden for providing fresh produce and preservables from spring to autumn and a winter garden providing products for storage and preservation. Distribution of the crop areas can be seen in Figure 8., while Table 11. summarizes crop yields and distribution.

The summer garden is 3000 m^2 large and it is situated in close proximity to the church, where the primary processing of the fresh cooking takes place (Number 1 in Figure 6.). The summer garden is constituted of the two glass greenhouses, the two foil greenhouses, one larger and several smaller fields for open- air production. The greenhouses are the production site for early spring and late autumn production of leafy greens and other short growing period crops, such as radishes. During the summer period, the large greenhouse is used for producing warmth- requiring plants, such as karela, peppers or cucumbers and during the wintertime allows for production of cold tolerant leafy greens and cabbages. The main crops of the summer garden open- air production are tomatoes, aubergines, peppers, beans, chard, radish, crops of the cabbage family, celery, cucumbers, zucchini, maize, herbs and strawberries. A new component of the open air production is perennial asparagus plantation that was planted in 2012 and will become productive in the 2014 season.

The winter garden is constitutes of several fields throughout Krishna- valley totaling 1,7 hectares. Crops in the winter garden are those stable vegetables that need to be grown in large quantities for storage and consumption throughout the year. The winter garden rotation includes 3500 m^2 potatoes, 3000 m^2 pumpkin, 2000 m^2 carrots, 1500 m^2 parsley root and 500 m^2 parsley roots.

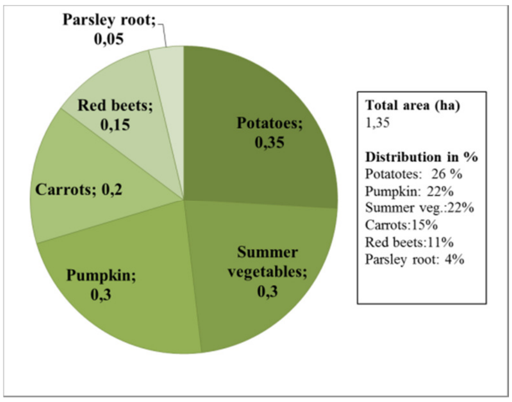


Figure 9. Crop areas in vegetable production

Crop management

Just like the variety selection, the development of the crop rotation is also based on the lifestyle and dietary habits of the inhabitants. The aim is to provide a continuous selection of fresh, stored and processed produce throughout the year. During the development of the rotation consecutive plants and companion planting are considered to provide optimal growing conditions. Consecutive planting of certain crops and avoiding some combinations allows for averting the building up of crop specific pests in the soil, while companion planting helps to attract mutually beneficial organisms and to dispel pests.

Seeds are prepared for seeding by soaking them in lukewarm herbal tea, milk or whey for 3- 48 hours. Herbs, such as yarrow, chamomile, thyme, calendula, comfrey, valeriana, oak bark and nettle are used. This procedure is claimed to shorten germination time by 1-2 weeks and to fortify germinating plants. The small greenhouse has wood heated warm beds that are used for preparing seedlings, which are planted in the compost produced from the vegetable garden. To prevent fungal infections, the compost is sterilized at 80 °C in an oven. Nettle, garlic and horsetail preparation are also used to water the seedlings and prevent infection. Seedlings are planted outside after 6-8 weeks of raising and fortified with a diluted nettle preparation. Seeding time for plants is based on the biodynamic moon calendar and weather conditions.

Nutrient management in the vegetable garden is based on animal manure and composting. Yearly 30 tons of stable manure is distributed in the summer garden in the autumn 50 tons of yard manure in the winter garden. Behind the vegetable garden a large area is available where composting of old mulch, weeds and green remains from the vegetables takes place, occasionally with addition of wood ash. All the organic waste is selected first and the compost is then organized to balance wet, dry, soft and hard materials, the ratio is usually 3:1 wet and dry ingredients. Weeds that were pulled after seeding are only mixed in the middle of the pile after the composting process has reached a high temperature to prevent repeated contagion. After maturing the compost in large piles throughout the year, it is then used in the spring starting seedlings and for adding nutrients when planting them out. When plants show specific symptoms of micronutrient deficiency, mineral fertilizers, such as alginit and plant extracts from comfrey and nettle are used. While nettle is considered to provide nitrogen, comfrey is used more as a general plant fortifier. The extracts are prepared by soaking the plants in larger containers for several weeks and then used in dilution for nutrient supply. In order to minimize soil loss through deflation, a protective windbreaker of trees surrounds the summer garden.

Pest management mainly relies on preventing large scale infestation by crop rotation, companion planting and leaf fertilizers. Pests affecting the vegetable production are mostly phytophthora, spider mite and lice, against which neem oil is used as a curative method. The infestation of weeds is prevented by mulching with straw or hay depending on availability.

Vegetable production relies exclusively on human labor and certain machines that accelerate management. Machines include a rotation plough for preparing beds in the summer, a gasoline powered sprayer for delivering nutritional liquids and natural fertilizers and a seeding machine used for seeding larger areas of vegetables. Irrigation is present in the summer garden in form of a drip irrigation system that is installed every year before laying down the mulch. Irrigation in the winter garden only occurs during extreme periods of drought, in these cases the fields are watered with a hose.

Labour

Unlike the animal husbandry and the plough field components, the vegetable component also makes use of external labour. In 2012, 2 full time Krishna volunteers, 2 full time external workers, 1 part time external worker and the director put in 8200 labour hours during the year, from which 7200 hours are required for crop management and 1000 hours for administration and farm management. The vegetable component is also the one that usually hosts occasional volunteers coming to Krishna- valley. While volunteers work 7 hours for 6 days a week, the hired external workers work 8 hours for 5 days a week, resulting in 40- 42 hours of labour per week. Large scale production in the vegetable garden is carried out from April to November, during the winter months only the director takes care of production in the greenhouse, storage and distribution. In this season the hired workers are not employed and the Krishna volunteers perform service by selling books in the larger cities of Hungary. The changing of the composition of the worker team has caused some problems in recent years, such problems is developing a team in a short time, training new people, not enough labor force to perform all required tasks (e.g. collecting wild plants)

Tasks to be performed in the vegetable garden include seeding, planting, weeding, irrigating generally managing the crops and harvesting. Besides the vegetable production, these workers are also responsible for helping out in fruit harvest, storage and processing of vegetables and fruits and distributing them to the church kitchen and the village store. One additional task of the director during the winter months is selecting and getting rid of spoiled products in storage. Administration, planning and distribution are the responsibility of the director of the department. The most labour intensive component of the vegetable production per area and in total is the summer garden, requiring 3600 hours of labour per year, while the winter crops are kept more extensively and weeded less. There is no available data however on the labour requirements of the different management tasks.

Crop products, processing and distribution

In 2012, the summer garden produced 5,8 tons of fresh vegetables, from which 50% was processed in the church canteen, 8% went to the Pujari for *prasadam* preparation and 9% were sold to the local community. The remaining 29%, 1,7 tons of vegetables, mainly tomatoes, pepper and green beans, were processed into preserves. The vegetables providing the largest amount of fresh product from the summer garden are tomatoes (2,2 tons), zucchini (0,6 tons), peppers (0,5 tons) and eggplants (0,4 tons). The main herbs produced in the garden are coriander, parsley and basil; all of which are important components of the *vedic* cuisine used fresh. Certain herbs are used also to provide raw material for medicinal apiary products.

Crops from the winter garden are used fresh in smaller quantities and mainly stored throughout the winter in the cellar. The highest yielding crop in the winter garden is pumpkin (7,5 tons), followed by potatoes (3 tons), carrot (2,2 tons), red beets (1,5 tons) and parsley root (0,3 tons). Root vegetables and peppers are stored layered in sand, potatoes in canvas bags and pumpkins on shelves. It is a general intent to store vegetables separately from fruits, to avoid over ripening or spoilage cause by the ethylene produced by fruits.

Table 11. Crop areas, crop products and destination of crop products in vegetable production. All amounts indicated in FM kg

Crop name	Area (ha)	Fresh yield (kg/ha)	Fresh yield total (ton)	Destination (kg) Church canteen	%	Pujari	%	Storage	%	Preservation	%	Sales	%
Summer vegetables	0,3	18600	5600	3100	17%	480	9%	0	0%	1700	30%	500	9%
Potato	0,35	8600	3000	2660	31%	660	22%	0	0%	0	0%	20	1%
Pumpkin	0,3	25000	7500	1090	4%	180	2%	6140	82%	0	0%	30	0%
Carrot	0,2	11000	2200	680	6%	60	3%	1460	66%	0	0%	30	1%
Red beets	0,15	10000	1500	460	5%	10	1%	1040	69%	0	0%	20	1%
Parsley root	0,05	6000	300	140	2%	0	0%	200	67%	0	0%	0	0%
Total	1,35		20100	8130	40%	1390	7%	8840	44%	1700	8%	600	3%

3.3.5. Fruit production

Fruit production in Krishna- valley serves the needs of the community for fresh and processed fruits. Fruit production has two main components, one being the production in orchards and the other the planting of fruit trees in grasslands and field borders.

Crop and variety selection

Fruit production shows a large variety of different species and varieties of fruit. The main goals when developing the selection of varieties were providing a large assortment of different fruits that enable continuous harvest due to a continuous ripening sequence and to collect and protect traditional heirloom varieties. Originally, the main orchards were planted with modern varieties. However, these did not perform well under the organic and extensive management methods and are gradually being replaced by heirloom varieties. The Hungarian heirloom varieties proved to be better adapted to these management conditions, more resistant and more resilient towards extreme weather conditions and pest infestation.

To acquire heirloom and specialty varieties, Krishna- valley has joined the National Pomology Network that provides information and fruit stock to members through exchange and sales. The head of the fruit department has received training in grafting through the Pomology Network, which allows for collecting and grafting fruits within Krishna- valley. Surveying and collection of scion from traditional varieties present in old orchards, farm remains and the landscape in Somogy county has been an ongoing project in recent years. The surveying relies strongly on local knowledge, resulting in discovering and saving leftover heirloom varieties that are adapted to local conditions. There is no exact data available on the number of varieties present and their scale of production.

Fruit production includes fruit species typical to Hungary, such as apples, apricot, cherry, pear, plum; berry bushes, such as josta, ribes, blackberries and nuts, such as hazelnut, walnut and almond.

Crop areas, yields and destination

Fruit production consists of two orchards, 0,7 hectares and 1,4 hectares, these include heirloom and modern varieties as well. Additionally, a small amount of fruit is produced in grasslands and field borders. A new plantation introduced in 2012 of 2 hectares will provide maroons, walnuts and almonds. There is no exact data available for exact number of fruit trees and varieties, however, yields and use of produce is presented in Table 12. In 2012, 6,2 tons of fruits were produced, apple and quince being the two fruits providing more than two thirds of yield, around 2 tons severally.

Table 12. Yields and destination of fruits

		Destination							
	Total yield (kg)	Pujari kitchen	%	Kitchen	%	Market	%	Preservation	%
Quince	2250	0	0%	100	4%	50	2%	2100	93%
Apple	2100	400	19%	150	7%	150	7%	1400	67%
Apricot	350	60	17%	60	17%	110	31%	120	34%
Cherry	320	90	28%	70	22%	10	3%	150	47%
Pears	280	90	32%	40	14%	60	21%	70	25%
Plum	220	50	23%	0	0%	90	41%	80	36%
Josta	170	60	35%	0	0%	40	24%	70	41%
Ribes	140	60	43%	0	0%	20	14%	60	43%
Walnut	110	110	100%	0	0%	0	0%	0	0%
Blackberry	75	75	100%	0	0%	0	0%	0	0%
Sour cherry	70	70	100%	0	0%	0	0%	0	0%
Peach	70	70	100%	0	0%	0	0%	0	0%
Gooseberry	62	22	35%	0	0%	0	0%	40	65%
Hazelnut	35	35	100%	0	0%	0	0%	0	0%
Almonds	10	10	100%	0	0%	0	0%	0	0%
Total	6262	1202	19%	420	7%	530	8%	4090	65%

Fruits are only used within the community and not being sold externally. 19% of the products are processed in the Pujari, the *prasadam* kitchen of the church, certain fruits and all nuts are exclusively used for preparing *prasadam.* Fruits are either used freshly by the canteen kitchen or sold at the local market. A substantial amount of fruits, 4 tons, 65% of all produce is processed into jams and chutneys for preservation during the winter.

Orchard Management

The main goal of managing the orchards is to prevent infestation of pests and diseases and to raise productivity. This management follows a strict technological regime developed over the years. The season starts in the winter – early spring during frost-free days and in accordance with the biodynamic calendar with pruning the trees. Wounds are closed off with a homemade wound dressing composed of plant oil, clay, fresh cow manure and cow urine. Cow manure and urine is considered to have antibacterial effects in *vedic* teachings. To prevent spreading of pests and diseases, tools are disinfected between trees.

From February to April the trees are provided with a wash- off spraying with cupric sulphate or lime and sulphate solutions. These compounds used for spraying are accepted in organic production. Nevertheless, copper solutions are only used curatively if trees show signs of disease. During the spring time, pest management is focused on monitoring and prognosis of insect population changes and prevention of large scale infestations. This is carried out with different coloured sticky plates that help determine pullulating of certain pests and timing of necessary spraying, while pheromone traps aid in precluding reproduction of insect pests. Ants, lice and caterpillar are retained from climbing on the trees with sticky belts installed around the tree trunks. In the autumn, the tree trunks are painted with a mixture of lime and clay in order to retain insects from climbing up the trees. The white tree trunks also reflect light during the winter months, which is considered to secure against frost damage.

Main pest problems in fruit tree management include apple scab disease (*Venturia inaequalis)*, codling moth (*Cydia pomonella),* plum moth (*Grapholita funebrana)* and different lice species. All infestations are treated with natural compounds, in case of scab disease the trees are sprayed with a solution of tansy (*Tanacetum vulgare*), lice and caterpillars are sprayed with plant based oils, such as rapeseed or thyme oil. Providing proper habitats for natural enemies, such as earwigs, also prevents lice infestation.

Nutrient supply of the orchards is administered during planting and every 3-4 years around the trunks in form of cow manure. Irrigation relies solely on rain and water retention through mulching around the trunks. Wind protection is implemented through protective shelterbelts of trees and bushes around the orchards.

Labour

The fruit production component is managed by the director alone who is responsible to carry out all management practices reviewed above. Like all volunteers, he also works 6 days a week for 7 hours a day, resulting in a 42 work hour week from February to October. External labor is only used for harvest when large amounts of fruits need to be harvested at once. In these cases, volunteers and hired labor from the vegetable production help out in the harvest. There is no data available for how long different management tasks and harvest take. Processing and distribution is managed together with the vegetable products by the director or vegetable production.

Processing and distribution

Fruits are stored, processed and distributed among with vegetable products. Besides using fruits fresh after harvest in the church canteen and the *prasadam* kitchen, fruits are either stored whole or preserved through various processing methods. Fruits suited for storage include apples and pears, the varieties that withstand months without spoilage are stored in the cellars on shelves and in crates. Since there is a high diversity of varieties in fruit production that results in different timeframes for storability, fresh apples and pears are available throughout the year.

Fruits that are not suited for storage, such as berries, peaches, apricots, plums and cherries are processed to allow preservation. Fruit preserves include canned goods such as jams and chutneys prepared with sugar. A sugar free option for preservation of cherries and berries is carried out with filling up jars of fruit with a mixture of hot water, salt and citric acid and then pasteurizing the closed off jars in hot water. Another preservation method for fruits is dehydration. This is carried it with a wood- fired oven designed specifically for dehydrating fruits. Besides this oven, fruits are also dried in the sun on frames covered in nets.

3.3.6. Other agricultural practices

Apiary, flower production and sylviculture were not researched in wide extent and were not included in the productive farm diagnosis due to their loose connection to agricultural production and methodological limitations in modelling. Sylviculture, however, will be discussed in more detail in the context of ecological infrastructure management. Below follows a short description of the apiary and flower components to complete the picture of agricultural production in Krishna- valley.

Apiary

Apiary production is aimed at producing high quality organic honey that is mostly used in culinary and medicinal practices. Currently, there are 100 bee families present in

Krishna- valley, managed by the director of apiary production. Although only 40 to 50 families could meet the needs of the inhabitants for honey, honey and herbal honey infusions are a valuable product marketed to tourists visiting Krishna- valley.

Since the relatively small area of Krishna- valley can be covered by the flying and pollen collecting distance of bees, a stationary production system is used; meaning that the hives are not moved around to follow flowering plants. The main crops from which pollen is collected are rape, acacia, sunflower and phacelia. Since the flowering time of these plants differs, single component honey can be produced. The honey production component is not organically certified, because of the varroa disease striking bee populations that currently can only be treated pharmaceutically.

Honey produced is not only used on its own as a natural sweetener, but along with pollen and propolis it provides raw material for *vedic* medicinal products. Healing honey products are prepared with infusion with different herbs and used among others as medicine against stomach and respiratory problems. The bees wax from the hives is utilized in cosmetic products and for making candles.

Flower production

Sacral services in the church require a large amount of flowers for decoration of the sanctuary, the building and as a sacrifice to Krishna. To be independent from external resources, flower production is performed on a scale of 0,5 hectares. The production is performed in open air and partly in an unheated greenhouse, therefore flower production between November and March is discontinued, during which time flower for sacrifice need to be imported from external sources.

Flower types grown show a high diversity, including bulb flowers, perennials, annuals, bushes, roses and flowering trees. Except for roses, bushes and trees, which are propagated and managed in a self- reliant manner, flower production relies on external seeds each year because of the use of highly decorative hybrid varieties.

Management of the flower garden is performed by the director of the component and a part time laborer. Nutrients are provided from composted manure and plant based compost. Irrigation is performed with a hose, water retention and weed suppression is provided by mulching with straw.

3.3.7. Ecological infrastructure management (EIM)

Role of EIM in Krishna- valley

EIM plays an important role in Krishna- valley with the goal to nurture natural processes that aid the goal of reaching self- sufficiency. To follow natural farming, natural habitats need to exist in the landscape, so the self- regenerating capacity of nature has to be nurtured and provide hibernation, shelter and feeding places for natural enemies of pests. High intensity farming is considered to destroy the natural restorative ability of the landscape, the soil and the natural habitats. On the contrary, traditional landscape farming is considered not only restorative, but even capable of raising biological capacity of an area. The aim of long- term self- sufficiency for food, firewood and other ecological services requires careful planning of resource availability and use, which relies strongly on managing the ecological infrastructure. According to Parta Das, it will probably take over 50 years to completely regenerate the ecosystem of Krishna- valley from high intensity agricultural production that was performed in the area during the last 100 years. Besides self- sufficiency, the management of the landscape and habitats is also important for spiritual reasons. As a spiritual centre and a site for several holy places, the site needs to be managed in a way that is both natural and aesthetically pleasing.

EIM is supervised through the board of agricultural production and carried out in each agricultural component through careful planning. Natural resource management and park management are individual directorates within the agricultural board that are responsible for EIM through management of the botanical garden, semi- natural and natural habitats, sewage treatment and sylvicultural production.

Ecological infrastructure is consciously managed in a way to create a diverse agroecosystem relying on natural processes to a high extent. In order to maximize the benefits of natural processes, the landscape was diversified by dividing large agricultural fields into smaller parcels, creating a mosaic of productive fields, woody shelterbelts, and natural and semi-natural habitats. The woody shelter belts provide habitat for natural enemies of pests, serve as a windbreak to prevent erosion and help to retain water. As put by Radhakanta Das:

> We have to be careful with erosion, that's why we have these tree rows to stop deflation, when the soil dries out and a wind blows away the fertile soil. It is good to have these plants against deflation, they also protect from erosion. It places like this it is good to have as much green as possible.

Botanical garden, natural and semi- natural habitats

The botanical garden was developed to provide an attractive landscape that is aesthetic and clean for people who live in and come to visit Krishna- valley. The botanical garden is considered as a secondary natural environment, where semi- natural elements are introduced in the landscape or preserved in their natural state. Besides its aesthetic role, the botanical garden also serves as a source for possible new varieties of plants that could be introduced into larger scale production in the flower garden or agriculture. The high species diversity also serves the purpose to preserve rare and exotic plant species and varieties.

The botanical garden is extended over 11 hectares and includes several natural and semi- natural sites that were preserved in the landscape along with 1000 different taxa of indigenous and exotic plants that were introduced. The grouping of plants is not based on taxonomy, but on the needs of plants and their matching habitats in the landscape. For example, subtropical plants are planted near buildings to benefit the warmth coming through the walls. In recent years, extreme weather conditions, such as long summer droughts and severe cold weather during the winter has caused dying off of certain plants in the collection.

Plants that were acquired from external sources for the botanical garden come from garden stores and specialty traders of rare species. The botanical garden has become member of the Association of Hungarian Arboretums and Botanical Gardens in 2012, but since it is currently under development it is not advertised as a tourist attraction. As Parta Das puts it, the botanical garden is still in its early stages:

> I believe now we have passed a first rhythm, a first planting of trees, bushes, mostly fast growing trees, plants which can offer fast results. Now we need to have a more thorough concept about the landscape to plan for a long time for more generations. This is when we need oak, hornbeam, ash, trees that are performing well here.

Semi-natural habitats are described as habitats where local flora and fauna is predominant, while natural habitats are areas where original vegetation is present in an undisturbed state. When Krishna- valley was founded, the area was mostly intensively managed plough field and pasture- only with small patches of semi- natural and natural vegetation left infested with invasive species. The habitats were freed from invasive species, such as acacia, *Fallopia japonica* and giant goldenrod (*Solidago gigantea*) to restore natural vegetation. Natural habitats remained in riverine areas in form of swamp meadows dominated by foxtail (*Allopercus)* species and certain woody patches with field maple (*Acer campestre*). These habitats were undisturbed by agricultural and sylvicultural production over the last decades and show a composition of natural flora typical to the region. Semi- natural habitats were restored by the ecological infrastructure management activity of Krishna- valley, such as riverine hydromorphic wetlands, *Alnus* forests, and dry grassland- bush mosaics. These habitats used to be under agricultural or sylvicultural production, and the semi- natural state of the habitats was restored by changing management practices, removing invasive species and allowing natural flora to redevelop.

The river running through the valley was swollen up in three places to create more wet biotopes.

Krishna- valley also holds several historical mementos, some of which are still visible in the area. According to personal research of Andras Kun, the top of the valley – the road that connects the stables with the church runs in the place of the ancient silk- road that used to connect Asian territories with the Mediterranean areas as a trade route during the Roman times. Although there is no physical evidence for this trade route, a name of a meadow known by locals still as silk- meadow was most probably a resting place for traders traveling through the silk- road. In the valley lies also a group of old oak trees over 100 years old, which were probably standing originally in the yard of archbishopric property. Although more recently built, the patios displayed in holy places all around Krishna- valley are also conspicuous elements in the landscape.

Sylviculture

Sylvicultural production serves three main purposes. Since electricity and gas is not introduced in Krishna- valley, all heating in the winter is reliant on wood- fired ovens, therefore sylvicultural production needs to serve the communities' needs for firewood. Besides firewood, woody areas also provide shelter belts for plough fields and other agricultural components and serve as habitats for natural enemies of pests benefiting agricultural production.

In 2013, 60 hectares were in sylvicultural production, from which not all forest areas were directly connected to the main area of Krishna- valley. The sites for new tree plantations were chosen because of their poor quality for agricultural production, but there are also forest areas that remained from previous owners of the area. To provide firewood fairly quickly, acacia was chosen to be the main firewood providing species, however, it does not perform very well under the climatic conditions of Somogy and it is an invasive species in Europe. Besides acacia, hornbeam and oak trees are present in sylvicultural production, but for their slow growing these forests are still considered young and not suitable to be used as firewood.

Sylvicultural management is strongly influenced by sylvicultural forest regulations, which determines forest species constitution, cutting regiment and other management plans. For example, in administered sylvicultural production the main tree variety in a new plantation needs to have at least 70% coverage and the management plan needs to be approved every 10 years by the regional sylvicultural directorate of the government. These restrictions apply to all existing forest, in practice hindering development of the forests with close to natural species composition. To overcome these restrictions, newly planted forests can be registered in a specific category that does not require such strict composition of species and continuous supervision. This way, in the future a mix- forest can be developed with Hungarian species native to the region.

Currently, the forest area covers the needs of the community for firewood, but only because the large scale production of the fast growing acacia. This scale of production does not allow however for using wood as a building material. According to Parta Das, if the community was to rely only on native hardwood species for firewood, forest areas need to be raised up to 100- 150 hectares and another 100 hectares would be required to provide sufficient building material for the community. Currently land availability in Somogyvámos and around Krishna- valley is very restricted and future development relies on

Water management

When choosing the site for Krishna- valley, water availability and quality was of central importance. Drinking quality water was required to avoid having to rely on external resources, therefor the area had to have its own water- collecting capacity. The valley surrounded by hills managed within the community enables controlling water quality continuously by averting leaching of nutrients from intensively managed farms in the surroundings. Water for home use and irrigation in agriculture is sourced from wells around the valley.

In agricultural production, both too much and too little available water can cause problems. Especially with the "rhapsodic" precipitation patterns of recent years, as put by Parta Das, can enhance these problems, resulting in high levels of rain during the spring and drought periods in the summer. Channelling away water during rainy periods is currently not developed to its fullest potential, although tree belts parallel with the slopes can help hold up excess water coming down the hills and avoid the wash off of nutrients. To save water resource quality several methods are used, such as shading surface waters, drip irrigation and mulching to ward off evaporation. Drought resistant varieties in plough field production make it possible to restrain from irrigating larger areas, which would be technically difficult, expensive and wasteful. The water quality is preserved by avoiding the use of chemicals in agricultural production and by constantly monitoring water samples from wells.

Surface waters, such as the two rivers, swollen up lakes and the final pool of the sewage treatment facility play an important role serving as a habitat for aquatic flora and fauna and creating a favourable microclimate for natural and semi- natural flora around the water banks. Aquatic flora and fauna also attract a wide variety of wild birds.

Sewage treatment

Water for households and communal buildings is provided from wells sourcing water from deeper soil layers. The mixture of grey and brown waters from the buildings reaches the sewage treatment facility by gravity without the use of external energy. Sewage treatment is carried out in a reed root zone sewage treatment facility.

When the sewage water reaches the facility, it first goes through a gridded structure to remove solid debris. Four sedimentation pools with anaerobic composting function with the goal to remove sediments and supernatant fractions of the sewage water. Sediments and supernatant fractions are cleared out regularly and composted with wood shavings under strict hygienic regulations to prevent hazards of infection. The compost is only used in non- food crops, such as the energy forest. The sewage water follows into a drainage system that leads to pools of reed root zone cleaning. The pools are isolated from the ground with a thick industrial textile and gravel coverage to prevent leeching of sewage water into the soil. The water flows through the root zone system and goes through anaerobic and aerobic processes in about 4-5 days, by which time the sewage water is cleared 95%. The remaining impurities, mostly ammonia and other nitrogen compounds are removed by aeration in a post treatment storage pool. This last pool resembles the look, flora and fauna of a lake, where fish were introduced and other wildlife had inhabited it.

Sediments and supernatant fractions are cleared out regularly and composted with wood shavings under strict hygienic regulations to prevent hazards of infection. The produced compost is only used in non- food crops, mostly in the forests. The water leaving the post treatment pools is used to water an energy forest of poplar and an experimental plantation of different bamboo species. These plantations were established especially for taking up the cleared sewage water and filter it into the soil, since it cannot be allowed back directly into natural waters. To avoid problems of nutrient leeching and hazards of infection, wells installed around the treatment facility are sampled regularly.

3.4. *Farming system diagnosis and discussion of results*

3.4.1. Diagnosis of productive farm performance

Crop rotations

The crop rotations of Krishna- valley were designed in a way to alternate between soil building and soil depleting crops. In plough field production, this is implemented by growing cereals or oil crops in the first year and a leguminous crop or a green manure crop in the second, as shown in Figure 7. in Chapter 3.3.3. Crop rotations in vegetable production were designed based on similar principles, although mostly focusing on pest suppression, since nutrients are supplied in a large quantity by animal manure. To avoid accumulation of pests, vegetables are grouped by family and type when designing the rotation. The areas of the different rotations and their components was shown in Figure 9. in Chapter 3.3.4., a summary of agricultural crop types is presented in Figure 10. All agricultural production is performed on 108,7 hectares, the largest constituent being grassland production serving as pasture to animals on 75,8 with addition of 10,25 hectares of alfalfa production for hay. Animal grazing and feed production requires over 80% of the total agricultural area of Krishna- valley. As will be discussed in the chapter of feed balance, this area would be capable of serving a larger herd, however it is in accordance with the traditional land use of extensive cattle grazing in the area. In overall agricultural production, cereals amount to 10% of land use with 10,7 hectares and oil crops to an other 3% with 3,22 hectares. If oil crops and cereals are considered soil mining crops; alfalfa and green manures, such as sudan grass and phacelia soil building crops, these two groups are represented to the same extent, 13- 14% of total areas in agricultural production.

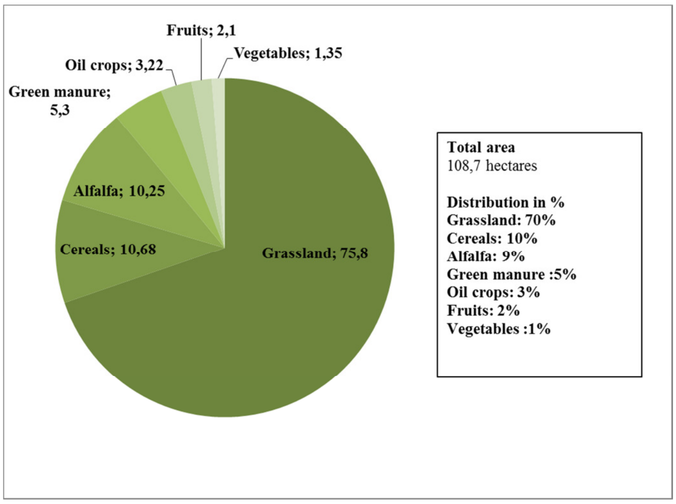


Figure 10. Agricultural crop areas by crop type in hectares and distribution in %

Crop yields and destination of crop products

Except for green manures sudan grass and phacelia and grassland production for pastures and hay, yield data relies on the production database of Krishna- valley. Green manure and grassland production yields were estimated based on data available in FarmDesign and expert knowledge.

Similar to the necessity of multifunctionality of crops for nutrient and pest management, also the multifunctionality of crop products is of importance in Krishna- valley. This is most prominent in the case of using cereal straw for bedding of animals and mulching and using leguminous crops, such as alfalfa for both animal fodder and green manure. As presented in Chapters 3.3.3- 3.3.5, crop products have different destinations within and outside of Krishna valley. Vegetables, fruits, nuts, and small scale produced plough field crops, such as sunflower and amaranth serve exclusively the needs of the community for food and for *prasadam* preparation. Barley, oats and grazed pastures are used only as fodder for animals. Marketed products include 100% of mustard seeds, 80% of wheat and 30% of alfalfa hay. The community relies on imports only for foods that are consumed by visitors to Krishna- valley. Animal feeding relies entirely on internal production.

Feed balance

The feeding regiment that was calculated in the model was balanced to provide adequate calories for the animals. Hay and grass consumption values were calculated according to a caloric balance, since the original data from Krishna- valley for hay consumption were higher than actual production and there was no data available for grass consumption of animals. After renewed correspondence it turned out, that certain amounts of hay is sold each year, but no exact amount was specified. After balancing the model for caloric intake, the final feeding regiment of the animals includes 351 tons of grass grazed, 89 tons of hay, 4,2 tons of barley and 2,6 tons of oats. Since the calves are allowed to suckle, their consumption of milk was also calculated into feed composition to the extent of 5000 liters per year, 7 liters per day per calf for 6 months.

The feeding balance of the grazing and the stable period is presented in Table 13. When the feeding regime was balanced for caloric intake, both protein and structure requirement are exceeded for the animals, while dry matter intake did not exceed the feed intake capacity of the animals (deviation <0). In general, the feed evaluation suggests, that feed availability and quality both meet the requirements of the herd, but that the ration is relatively rich in protein. This data however should be treated with sustenance, since no measurements were carried out in Krishna- valley concerning feed value of crops and specific requirements of the animals.

Table 13. Feed balance of animals during the grazing and the stable periods and deviation from requirements

	Period	DM intake (kg)	Energy (feed unit)	Protein (g)	Structure
Total available	Grazing Period	77892	55210	6093	141606
Deviation		-40%	-1%	285%	102%
Total available	Stable period	83813	53606	4819	247488
Deviation		-37%	0	194%	102%

Organic matter balance

Since there is no available data of SOM degradation rates in Krishna- valley that vacates reserves, the analysis was carried out comparing an assumption of 0% and 2% SOM degradation yearly, this latter being a data of Groot et al., 2010; which cannot be used with certainty under different climatic conditions of Hungary and the Netherlands.

Table 14. On farm soil organic matter (SOM) balance in kg assuming 0% and 2% yearly SOM degradation

SOM degradation	0%		2%	
Inputs	**Per farm**	**Per hectare**	**Per farm**	**Per hectare**
Crop residues	132092	1215	132092	1215
Green manures	9720	89	9720	89
Own manure	57567	530	57567	530
Imported manure	0	0	0	0
Outputs				
Manure degradation	44473	409	44473	409
SOM degradation	0	0	309638	2849
Erosion losses	212	2	212	2
Total inputs	199379	1834	199379	1834
Total outputs	44685	411	354323	3260
Balance	154694	1423	-154944	-1426

Table 14. shows the balance of SOM in the farming system of Krishna- valley, assuming 0% and 2% degradation yearly. The 200 tons of SOM input yearly is a result of crop assimilation and input in form of crop residues and green manures (142 tons) and manure from the animals (58 tons). 44 tons of the 58 tons manure inputs is degraded, erosion only contributes to losses on a minimal level (0,2 tons). If SOM degradation is considered 0%, the balance of SOM is positive, however, with 2% yearly degradation, crop assimilation and manure inputs cannot compensate for losses to degradation, resulting in a negative SOM balance of 159 tons on the farm level and 1,4 tons per hectare. The system almost in a balanced state assuming 1% yearly SOM degradation, in which case the SOM balance in -1 ton/ha.

Manure

Animal manure in mixed farming systems helps to distribute nutrients among different components (Watson, 2002). Yearly, around 100 tons of farm yard and stable manure is distributed among wheat and vegetables, while pasture manure is left on the fields. For modelling, only the ratio of fresh manure was considered for application, since FarmDesign calculates manure production in dry matter kilograms. Since the areas of home garden vegetable production are not considered in the model, application of those 40% of manure is not considered. However, manure production was set to full self- supply, so this amount is still considered in nutrient dynamics in the model.
Table 15. shows application rates of manure acquired from Krishna- valley and conversion of these ratios to DM application/ ha. Altogether, 250 tons of manure is distributed yearly among vegetable, wheat and home garden production. In wheat and vegetable production, the manure distributed accounts to 36- 40 tons/ hectare. Converting to application in DM, the manure distributed is 8000- 9000 DM kilograms/ha. Table 16. shows manure production per type, application rates per crop and organic matter and nutrient contribution to soil. These results will be discussed among nutrient cycles in the following chapter.

Table 15. Manure production, application rates and contribution to nutrient supply a.) Production and applicable amounts of different manure types, b.) Distribution of manure among crops c.) Contribution of manure to nutrient supply

a.)

Crops	Manure type	Area	Total applied FM	Ratio	Applied DM	DM/ha
Wheat	FYM	2,5	100	0,4	22800	9120
Vegetables	FYM	1,4	50	0,2	11400	8143
Home gardens	FYM+SM	na.	100	0,4	22800	n.a.

b.)

Name		DM (kg)	OM (kg)	C (kg)	N (kg)	P (kg)	K (kg)
Farm yard manure (FYM)	Production	73617	65654	32827	2111	402	2507
	Applicable	44612	39786	19893	1791	402	2507
Pasture manure (PM)	Production	8493	7413	3707	546	79	709
	Applicable	5521	4818	2409	518	79	709
Stable manure (SM)	Production	20499	17892	8946	1317	191	1712
	Applicable	12423	10843	5421	1105	191	1712

c.)

Manure name	Name	Crop area (ha)	Total DM (kg)	DM/ha (kg)	N/ha (kg)	P/ ha (kg)	K/ ha (kg)
FYM	Potato	<1	2849	8140	333	73	457
	Carrots	<1	1628	8140	333	73	457
	Beetroots	<1	1221	8140	333	73	457
	Parsley root	<1	407	8140	333	73	457
	Pumpkin	<1	2442	8140	333	73	457
	Summer vegetables	<1	2442	8140	333	73	457
	Wheat 2	2,5	22800	9120	373	82	513
	Grassland	14	12880	920	86	13	118

PM	(cutting+grazing)						
	Grassland (grazing)	28	51152	1840	173	26	236

Nutrient balance

In the agricultural system of Krishna- valley, external resources of nutrients are only used to a minimal extent, therefor it is of central importance how the internal nutrient cycles deplete or augment soil nutrient reserves. Inputs rely on crop assimilation of carbon and nitrogen, atmospheric nitrogen fixation and freeing soil reserves of other macronutrients, such as phosphorus and potassium. Although some external mineral fertilizers are used in vegetable production, these are only applied on less than 1% of the total agricultural area and the applied amount is not registered in the databases. It is for these reasons, that these inputs were not considered in the model. Figure 11. shows the nutrient cycles of carbon, nitrogen, phosphorus and potassium in the agricultural system.

Crops assimilate carbon through photosynthesis; this process provides the basic input as soil carbon that accounts for 1,6 tons of carbon entering the agricultural system each year. The carbon from crops either goes straight to the soil in form of crop residues (654 kg/ha) or enters a cycle through animals and manure (762 kg/ha). Carbon leaves the system through crop exports, animal respiration, milk products, and degradation of manure and soil organic matter. After these processes, the balance carbon in the system negative, accounting for a negative balance of 180 kg/ hectare. crop exports account for 150 kg of this negative balance.

The main source of nitrogen in a self- reliant farming system is atmospheric nitrogen fixation of leguminous crops. In Krishna- valley, these crops are represented by alfalfa and clover in plant mixtures of grassland production, fixing an estimated 46 kg of nitrogen/ha yearly. Besides symbiotic nitrogen fixation of leguminous crops, microorganisms in soil also fix atmospheric nitrogen, and along with deposition of nitrogen these non-symbiotic nitrogen sources provide 17 kg of nitrogen/ha/year. Losses of nitrogen occur through crop export, volatilization processes during storage and application of manure, erosion and soil losses. Overall, the nitrogen budget of Krishna- valley is positive by 53 kg/ha/year, which is lower than the amount fixed by leguminous crops. This indicates that leguminous crops play a central role in preventing depletion of soil nitrogen reserves on the long run.

Phosphorus and potassium are nutrients that cannot be assimilated by crops from the atmosphere. The supply of these nutrients in organic farming systems is often resolved by applying mineral fertilizers. Since Krishna- valley tries to be independent of external resources, especially if their production is considered unsustainable, as is the case for mining mineral fertilizers. Phosphorus and potassium are both present in soil in deeper layers and organic forms are not as prone to leaching as nitrogen. These reserves can be exploited by crops with deep roots, and made available to following crops as green manure. However, the reserves can become depleted over the years, as is the case in Krishna- valley, showing negative balance for both phosphorus and potassium in the agricultural system due to crop export and losses in the soil.

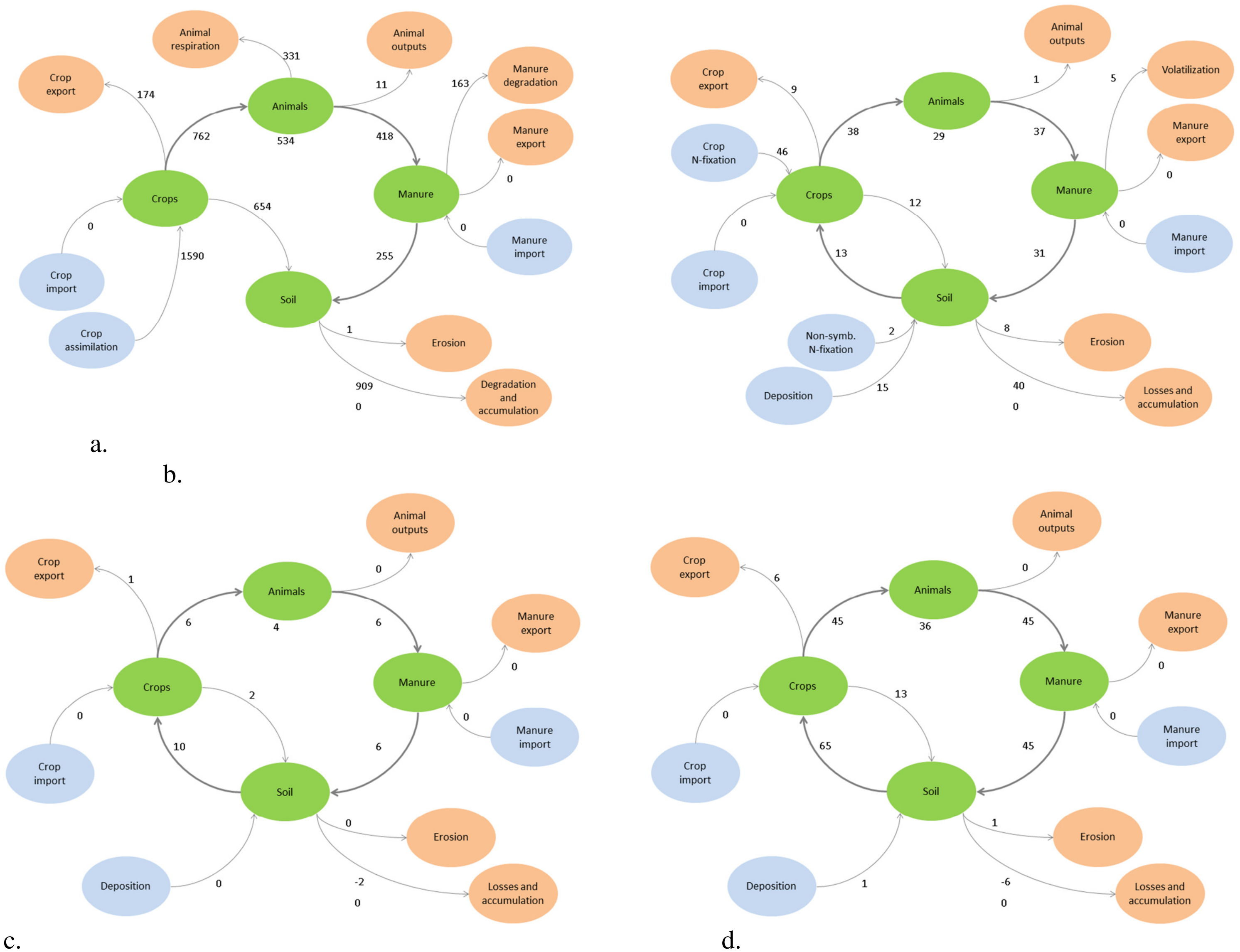


Figure 11. Nutrient cycles of the farming system. a.) Carbon b.) Nitrogen c.) Phosphorus d.) Potassium.

Table 16. Distribution of labour between departments, labour type and season, composition of available labour hours

Department	Labour type	Number of workers	Hours/ day	Days/ week	Season	Months/ year/worker	Days/ year/worker	Hours/year/worker	Total labour hours	Distribution of labour hours			
										Farm management	**Herd management**	**Crop Labour**	**Herd Labour**
Vegetable production	Volunteer	2	7	6	April - November	8	208	1456	2912	1306	0	1606	0
	Head of department	1	7	6		8	208	1456	1456	1456	0	0	0
	Hired labour (causal part time)	1	4	5		8	192	768	768	0	0	768	0
	Hired labour (casual full time)	2	8	5		8	192	1536	3072	0	0	3072	0
Dairy	Volunteers	3	7	6	January-November	11	286	2002	6006	0	406	0	5600
	Head of department	1	7	6		11	286	2002	2002	0	2002	0	0
Oxen work	Volunteers	4	7	6		11	286	2002	8008	900	1008	1300	4800
Fruit production	Volunteer (director)	1	7	6	March.-Nov.	9	234	1638	1638	0	0	1638	0
	Hired labor for harvest								300	0	0	300	0
	Locksmith	1	7	6	10 months/ year	10		1760	1760	1760	0	0	0
Farm management	Director	1	7	6	Whole year	12	309	3708	3708	3708	0	0	0
Flower production	Volunteer (director)	1	7	6	March.-Nov.	9	234	1638	1638	0	0	0	0
	Hired labor (part time)	1	4	5	March.-Nov.	9	234	936	936	0	0	0	0
Apiary production	Volunteer (director)	1	7	6	March.-Nov.	9	234	1638	1638	0	0	0	0

Labour

As described before Chapter 3.3. , there are three different labour types performed in Krishna- valley; the volunteer work of the *bhaktas*, external hired labour and volunteer work of visitors to Krishna- valley. Labour hours per labour type and agricultural component are presented in Table 16 and Table 17. shows a summary of labour hours. In 2012, 13 volunteers and 4 hired workers performed labour in agricultural production, resulting in 31630 hours of labour during the year, excluding flower and apiary production.

Labourers work different hours per day, but also during different times of the year according to seasonal workload. Generally, the winter months require less labour due to no crops present and no grazing during this season. Hired labour during these times is not present on the farm and *bhaktas* perform service outside of Krishna- valley. Directors of the components are usually responsible more for farm management tasks and less for actual physical labour, while other volunteers and hired labour perform all crop and herd related tasks.

The largest component of labour is connected to tasks with the herd, such as taking care of the animals, milking, cleaning stables and yards; but also milk production is included in this component, although there is no data as to which extent. Farm management is the second biggest component of labour, including work performed by the locksmith for improving and maintaining machinery, tasks with storage and distribution of products, managing labour, administering production and planning future management. Although not directly connected to agricultural production, farm management also includes keeping in contact with professional and scientific partners and organizing research in agriculture. Crop labour is most time consuming in the vegetable production due to manual crop management, such as hand seeding, weeding and harvest. Crop labour for plough field production consists of management with the tractor and oxen, these latter being the more labour intensive, as discussed before in Chapter 3.3.3.

Labour availability is a limiting factor in extending agricultural production and population size in Krishna- valley. Full self- sufficiency for food in the understanding of the community would require relying solely on internal labour of the community and excluding tractor work from plough field management. To reach these goals, population size, herd size and agricultural production need to extend in a harmonized manner, since these three factors are strongly interconnected.

Table 17. Summary of labour hours in agricultural production

Family labour	27490
Casual	4140
Total	**31630**
Farm management:	9130
Herd management	3416
Crop labour	4544
Herd labour	10400

3.4.2. Optimization scenarios for improvement

Process of optimization

The diagnosis process revealed that the major limiting factors of productive farm performance in Krishna valley are labor and the lack of external inputs combined with exporting crop products. While atmospheric nitrogen can be fixed with introducing leguminous crops into the rotation and carbon is sequestered through photosynthesis, the mining of other nutrients, such as P and K can pose a threat to maintaining relatively high yields on the long run. Results also show an excess of protein in the diet of cattle. The first round of optimization was performed to maximize nutrient balances of C, N, P and K and minimize the excess protein in the diet of the animals through different scenarios of crop areas and product use. To leave more room for balancing animal diets, a low protein alternative feedstuff, the straw from different cereal crops was also enabled for cattle feeding. For the same reason, straw, grassland and hay were enabled to be used as green manure. The optimization process did not include vegetable crops and fruits, since these areas are relatively small compared to the whole farm area and provide the necessary fruits and vegetables for the community. SOM degradation was considered 1% annually, as this rate showed an intermediary between the two possibilities discussed in Chapter 3.4.1. The second optimization was performed to maximize labor balance and SOM balance to reveal synergies and tradeoffs between these two most important factors.

Results for optimizing soil nutrients and feed balance of cattle

As can be seen in Figure 13., raising the balance of soil C, P and K through optimizing crop areas and crop product destination is only possible until a limit that is still negative or 0. On the other hand, as seen in Figure 13., the balance of nitrogen can be optimized relatively higher from the origo than those of other nutrients. The most optimal scenarios for C, N, P and K balance are the same, meaning there is a synergy between the optimization of these nutrients. A scenario for further analysis was chosen at the highest value for nutrients, *CNPK max.* Figure 12. shows the optimization cloud for factors of CP deviation in the grazing and the non- grazing period. Although a positive balance cannot be reached within the limits of crop areas and feedstuff, there is an optimization process that shows a pareto- optimal distribution for grazing period and non- grazing period CP balance. Therefor two scenarios were chosen for further analysis, namely *NGP min*, for minimal CP deviation in the non- grazing period, and *GP min* for minimal CP deviation in the grazing period.
A summary of nutrient balances, CP deviations, composition of crop areas and distribution of crop products for the original setup and the different scenarios is displayed in Table 20.

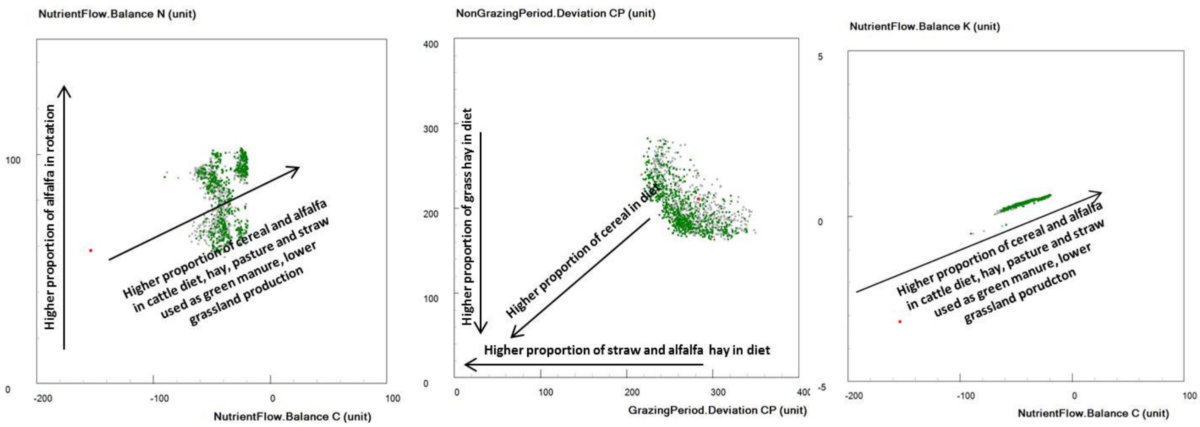


Figure 13. Clouds of optimized scenarios for improving nutrient balance of soul and CP balance of cattle diet

The optimization process shows synergies for all objectives in certain tendencies. Cereal production and green manures have results of higher crop areas, while the areas of other plough field crops, such as mustard, amaranth and sunflower are lower compared to initial point. This tendency can be accounted to the fact that these latter crops are only used for home- consumption and do not provide other services, such as feed for animals or crop residues. It is important to point out however, that this is a limitation of the initial input for the model, since there was no data available as for how the residues of these crops are used. With the enlarged areas of cereal production, cereal grains and straw are represented in the feeding regime to a higher extent compared to the initial state. This result suggests that introducing straw and increasing amounts of cereal grain in cattle diet could be advisable for improving nutrient balances and reducing excess protein in cattle diet.

Table 20. Summary of results for optimized scenarios

	Original	CNPK max	NGP min	GP min	OM max	LAB max
Feed Balance						
Grazing Period CP deviation	284	291	295	208	318	293
Non- Grazing period deviation	194	158	136	229	249	270
Nurient Balance						
C	-181	-32	-57	-44	-69	-107
N	53	99	54	77	63	94
P	-1	0	0	0	0	-1
K	-5	0	0	0	0	-1
Rotation						
Cereals	10,3	14,8	10,7	16,7	34,2	25,1
Green manure	5,3	5,7	4,7	7,3	4,8	10,3
Other plough field	3,7	1,3	1,4	2	2,8	17,2
Alfalfa	10,3	24,7	7,6	17,3	13,1	27,5
Grass Cutting	28	12,6	30,2	25,1	10,3	1,7
Grass C+G	14	12,7	14,5	6,9	8,5	13,1
Grass grazing	27,8	2,7	31,7	1,2	26	3,8
Grass Total	69,8	28	76,4	33,2	44,8	18,6
Product use						
Cereals to animals	6004	31759	16458	22609	54032	46158
Straw to animals	0	11058	1288	6743	23582	16318
Straw to field	8910	3378	8013	6184	46133	29819
Straw to bedding	31635	48323	32121	50123	62134	49525
Alfalfa hay to animals	22181	59657	10017	36299	23033	25523
Alfalfa hay to field	0	22308	11297	16426	14110	67882
Grass hay to animals	46408	28379	63265	47531	11718	13375
Grass hay to field	0	5797	4190	3896	14578	1556
Pasture to animals	70769	20563	50446	9505	29451	27277
Pasture to field	24831	70903	50671	63814	50348	19161
Organic Matter						
Balance	-1	156	68	126	206	131
Labour balance	-11	112	-116	342	2376	3049

CNPK max shows higher areas of cereal and a doubled alfalfa production areas and a significant reduction in grassland production, especially for pastures used only for grazing. This distribution for crop areas is also reflected in the composition of cattle diets, with 80% of the energy requirements being sourced from grains and hay, even in the grazing period. This could be explained by the higher energy ratio of these cereals and hay per DM compared to grass, removing less DM and with it, less nutrients from the fields. This also results in an enlarged CP deviation in the grazing period, while the in the stable period CP deviation is improved. A substantial amount of hay and grassland is used as green manure in this scenario, both SOM and labor balance are improved.

GP min shows higher areas of alfalfa and cereals, thus an extended proportion of cereals, straw and alfalfa hay in the diet of animals during grazing period. The setting of the optimization did not set a minimum requirement for proportion of grass in the diet to leave room for scenarios and better explore tendencies, therefor the unusual results of low proportion of grass in the diet, as shown in Table 21. Compared to the original state, *GP min* shows increased proportion of energy provided from cereals and grass hay, while reduced proportion of energy provided from alfalfa hay.

Table 21. Energy provided and proportion of total energy intake for optimizing grazing period and non- grazing period CP deviation. GP: Grazing period; NGP: Non- grazing period

		Original GP	***GP min***	**Original NGP**	***NGP min***
Cereals	Energy provided	2968	19619	2963	3443
	Proportion of total	4%	43%	6%	8%
Grass hay	Energy provided	3433	16450	32427	32604
	Proportion of total	5%	36%	63%	74%
Alfalfa hay	Energy provided	16478	2927	16478	8024
	Proportion of total	24%	6%	32%	18%
Pasture	Energy provided	46122	6995	0	0
	Proportion of total	67%	15%	0%	0%
Straw	Energy provided	0	2154	0	166
	Proportion of total	0%	5%	0%	0%
Total energy		69001	45991	51868	44071

NGP min shows reduced production areas of cereals and alfalfa, and raised areas of grassland both for cutting and grazing. As pasture grazing is not present during the winter, the raised areas of grassland result in a tradeoff of CP balance in the grazing period. As for the non- grazing period diet, compared to the original state, a higher proportion of energy from cereals and grass hay and a lower proportion of energy from alfalfa hay resulted in *NGP min.* Straw did not come up as a significant supplement for diet in the non- grazing period.

Although in an extensive grazing system, grazing period diet of cattle should mainly comprise of pasture grass, the tendencies of the optimization show, that it would be advisable to reduce proportion of alfalfa hay and use cereals, grass hay and a low amount of cereal straw during the grazing period for supplementing cattle diet in order to minimize the protein surplus. On the other hand, straw did not get introduced during the non- grazing period, with grass hay dominating over alfalfa hay.

Results for optimizing SOM and labour balance

Figure 14. shows the clouds of optimized scenarios for the second optimization process. Both OM and labour balance can be improved through changed distribution of crop areas and crop products, OM balance is improved from -1 kg/ha to 206 kg/ha, while labor balance is improved from -11 hours/ year to 3049 hours/ year. The two maximum values for the parameters do not fall into the same scenario, therefor two scenarios were designated for

further analysis, namely *LAB max* for the highest labour balance and *OM max* for highest soil organic matter balance. General tendencies can be observed also in this optimization process, C and N balances are improved compared to the original, cereal and alfalfa areas are raised, and total grassland areas reduced. In product use, a reduced input of pasture grazing is combined with higher proportion of cereal and straw in the diet, and a substantial amount of hay, grassland and straw being used as green manure for the field. However, there is a pareto-optimal distribution of solutions for balancing labour and SOM, meaning there are tradeoffs between optimizing these two parameters. *OM max* shows a positive labor balance of 2400 hours/ year, and *LB max* a positive OM balance of 130 kg/ha/year, meaning it is possible to optimize both parameters until these points simultaneously. Previous parameters were also visualized, while there is no correlation of optimization between OM and labour balance with grazing period and non- grazing period CP deviation, there is a pareto- optimal distribution of solutions for optimizing OM balance with N balance. Labour balance and N- balance are positively correlated, showing the maximum balance for both parameters in the same scenario, namely *LB max.*

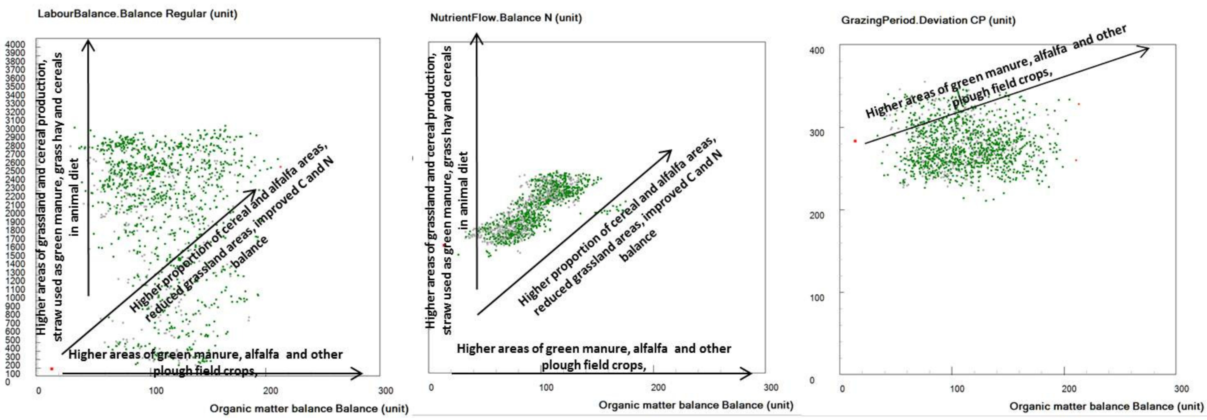


Figure 14. Clouds of optimized scenarios for improving labor and soil organic matter balance

OM max shows a higher C balance and a lower N balance as compared to *LB max*. This tendency can be explained by the crop areas and destination of crop products, *OM max* shows higher areas of cereals and grass, a higher proportion and amount of straw and grass hay being used as green manure, while *LB max* shows higher areas of green manure, alfalfa and other plough field crops, with green manure being applied in form of alfalfa hay. The optimization for lower grass areas and higher cereal and green manure crops is understandable, since hay production is the most labour intensive task in plough field production. The high proportion of grass hays and cereals in *OM max* in the animal diet also explains why the results are optimal also for non- grazing period The use of different crop residues for enhancing N and OM balance can be explained by the relatively low N- content of cereal straw and grass compared to alfalfa. The trade- off between balancing OM and N can be accounted to this. Green manure and other plough field crops have lower labour requirements, but cannot compensate for OM loss through the lower amount of carbon rich green- manures, such as straw.

3.4.3. Performance in ecological infrastructure management

Agroecological layout and management

Figure 15. shows the spatial image of Krishna- valley, its agricultural components and landscape elements. The ecological network of the agroecosystem consists of forests, woody shelterbelts, the botanical garden, other semi- natural elements in the parks and surface

waters. On the southern side of Krishna- valley, the plough fields are divided with woody shelterbelts that connect to larger forest elements, which also surround the lakes and rivers running in the valley. Through its connectedness and large area, this network can be considered as a single robust landscape element. On the northern side of the valley, the larger grassland areas are less divided by woody shelterbelts, resulting in larger field size and lower presence of robust elements. It can be seen in the map, that while Krishna- valley shows a mosaic like structure of productive fields and ecological infrastructure components by division of fields with tree borders and embedding productive fields in forest areas, the surrounding landscape is less diverse, with larger arable land field and less division by woody shelter belts. The outer- fields of Krishna- valley, the fields that are outside of the main area also show a more homogenous picture, although the fields are still smaller than those of the surrounding agricultural landscape. While parks, semi- natural habitats and surface waters are present in Krishna- valley, they are completely lacking in the surrounding agricultural landscape and only scarcely present in the village of Somogyvámos in form of home gardens. Due to the small size of these, they are not indicated in the map.

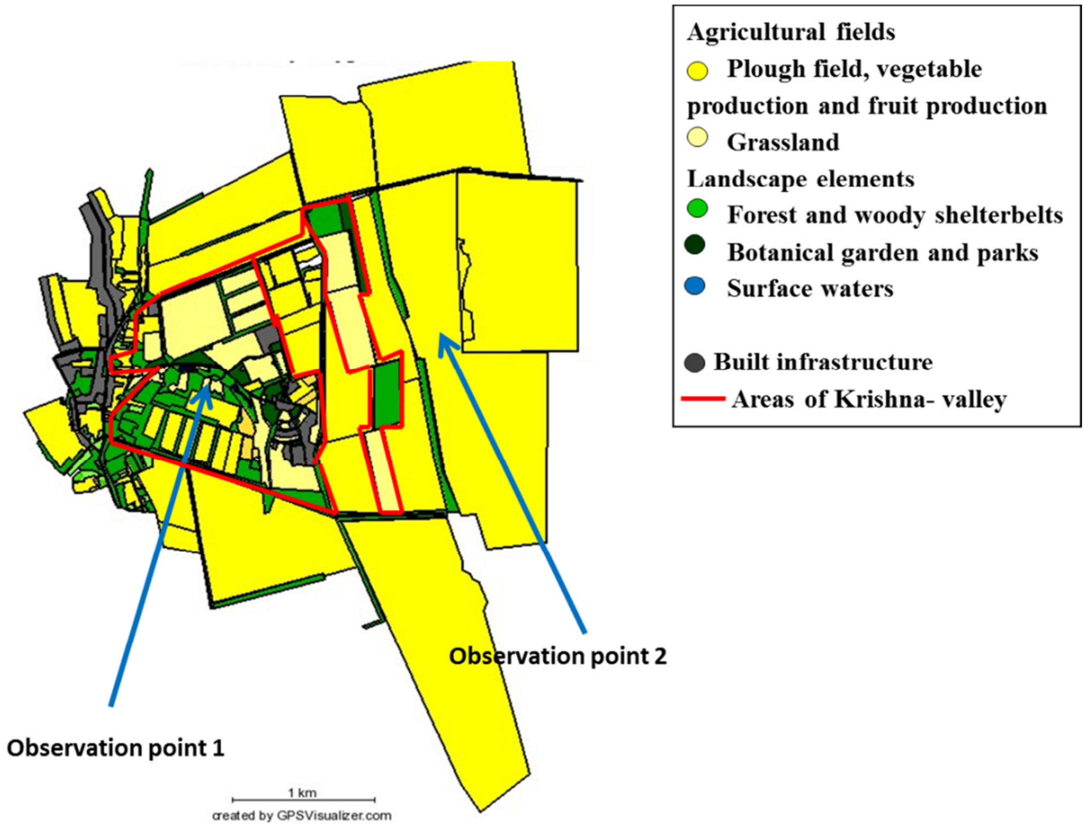


Figure 15. Land use patterns in and around Krishna- valley

The observation points designated in LandscsapeLab are indicated in Figure 14. with the blue arrows, while Table 22. shows the land-use gradients within the above mentioned radiuses.

Within 100 and 200 meter radii of the observation point, mostly grassland and parks are dominating the landscape within Krishna- valley. The composition of land-use types gets more diversified with the larger radiuses that cover most of Krishna valley. Within the 1000 meter radius, ecological infrastructure components, such as forests, woody shelterbelts and grasslands with bushes cover altogether 23% of the total area. Grassland and arable field production cover 26% and 42% of the 1000 meter radius respectively, although this share of land- use is lower for arable production and higher for grassland production within a 500 meter radius. In comparison with the observation point outside of Krishna- valley, these results show a much higher diversity of land- use patterns. Coverage of ecological infrastructure elements is under 15% in a 1000 meter radius and 0% in a 200 meter radius. These results show, that land- use in Krishna- valley is much more diverse than in its approximate surroundings, however, the forest coverage still does not meet the 32% of Somogy county.

Ecological infrastructure index (EII) provides the percentage of the farm that is managed as a network of ecological infrastructural components. The target of the EII is 5%, which is exceeded in Krishna- valley, the total area in EIM resulting to 23% by the land- use analysis (Hopster and Visser, 2002).

The calculation of the FSI:

A1= 18+10,6+7,5+2,4+3,2+3,1+6,2+8,2+8+7,4+5,4+3+3,7+3,6=90,3
W1=(420+200+180+130+120+110+180+210+150+180+140+120+150+170)= 176
At= 108
FSI= (90,3*(176-125)/108)= 42,6

Based on these calculation, the FSI in Krishna- valley is 42,6, which indicates, that the field sizes are more than optimal for supporting functional biodiversity and the dispersal capacity of natural enemies.

Spatial coherence of landscape elements was analyzed with LandscapeLab, the results can be seen in Figure 16. The largest area of connected habitat patches is 50 hectares, supporting the dispersal on insects between 300 and 500 meters. Dispersal distances between 50 and 250 meters is supported by an area of 30- 35 hectares.

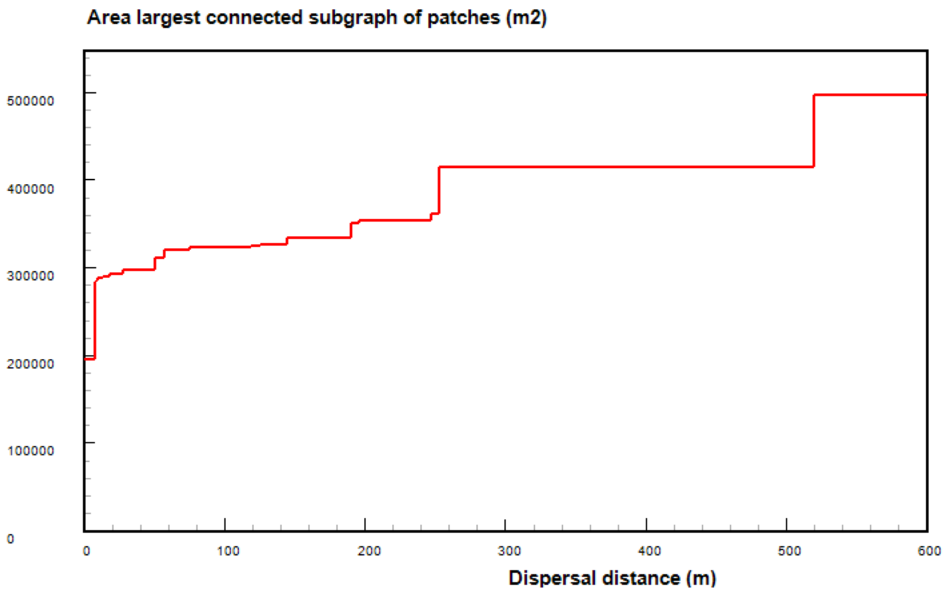


Figure 16. Graph of spatial coherence

Table 22. Land use- gradients within and outside of Krishna- valley from the observation points

Krishna- valley

Range (m)	Vegetables	%	Road	%	Border	%	Dwelling	%	Forest	%	Grassland	%	Arable	%	Woody	%
100	0	0%	435	1%	870	3%	0	0%	562	2%	16352	53%	0	0%	0	0%
200	0	0%	6280	5%	8312	7%	0	0%	22744	18%	67075	53%	0	0%	0	0%
500	16829	2%	23134	3%	64941	8%	10883	1%	100381	13%	298615	39%	160004	21%	12569	2%
1000	26831	1%	14663	5%	321710	10%	100691	3%	322000	10%	817432	26%	1343706	42%	23275	1%

Range (m)	Building	%	Lake	%	Park	%	Garden	%	Vineyard	%	Sewage	%	Honeybees	%	Total
100	994	3%	0	0%	11784	38%	0	0%	0	0%	0	0%	0	0%	30997
200	1885	2%	2985	2%	16259	13%	0	0%	0	0%	0	0%	0	0%	125540
500	36834	5%	5871	1%	50173	6%	0	0%	5910	1%	0	0%	0	0%	773575
1000	36834	1%	5953	0%	58169	2%	7258	<1%	5910	0%	3328	<1%	1100	<1%	3197295

Surroundings

Range (m)	Vegetables	%	Road	%	Border	%	Dwelling	%	Forest	%	Grassland	%	Arable	%	Woody	%
100	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	31368	100%	0	0%
200	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	125069	100%	0	0%
500	0	0%	0	0%	32210	4%	0	0%	21185	3%	4455	1%	721538	93%	0	0%
1000	2229	<1%	5465	<1%	118800	4%	0	0%	83606	3%	221258	7%	2605694	86%	2335	<1%

Range (m)	Building	%	Lake	%	Park	%	Garden	%	Vineyard	%	Sewage	%	Honeybees	%	Total
100	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0		31368
200	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0		125069
500	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0		779388
1000	956	<1%	0	0%	0	0%	0	0%	5126	<1%	0	0%	0		3045469

Landscape analysis
Chapter based on Stobbelaar & Hendriks (2006)

Table 23. shows a summary of the expression of different landscape coherence aspects in Krishna- valley and their positive or negative effects on landscape legibility.

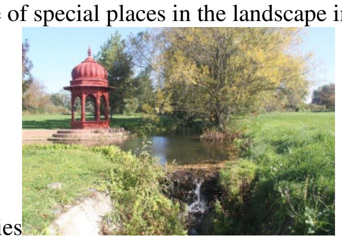
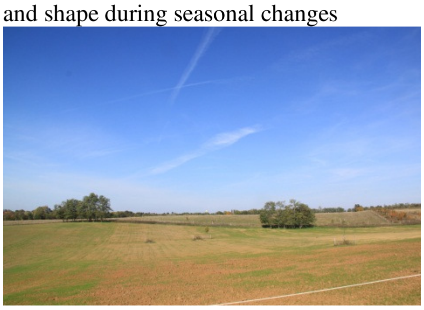
Vertical landscape coherence is negatively affected by the presence of large areas with monotonous species composition, such as reseeded grasslands and acacia forests. The landscape is also more homogenous in young plantations of the botanical garden and woody areas. However, this homogeneity is only temporal and will develop into a more heterogeneous landscape over time. On the other hand, vertical coherence is strengthened by the large agrobiodiversity of crops and management practices and by the mosaic-like landscape structure created by forests, tree borders, natural and semi- natural areas and wet biotopes. Vertical coherence is expressed in the presence of habitats typical to the region, such as meadow grasslands, riverine tree associations and semi- arid habitats of bushes and trees. The special elements of the landscape strongly influencing horizontal coherence are the sanctuaries, which by their presence and similarity connect otherwise unconnected landscape elements. The whole of Krishna- valley is connected to the wider surroundings and the region by the presence of crop and native plant species typical to the region and a coherent ecological network. The horizontal coherence is low with the immediate surroundings, as the smaller field size, the more mosaic like landscape structure and the low intensity management differs strongly from the surrounding large farms managed intensely. This weakness in horizontal coherence however can not be perceived as a negative attribute, since the differences are consciously generated to the benefit of the landscape and the community.

Seasonal coherence is present all around Krishna- valley due to the high variety of crops, planted and native flora with the exception of freshly seeded grasslands, that do not show changes in shape and color during the year.

Historical coherence is weak in the sense that there are no built historical structures present. Historical coherence is also weakened by the presence of buildings in the landscape that are not typical to the region, such as the Krishna- temple or the barn. However, these buildings also strengthen historical coherence on a wider scale, being traditionally designed as holy places of Krishna- consciousness. The presence of native flora and fauna, traditional crop varieties and management methods also positively influence historical coherence on the regional level.

All in all, the landscape of Krishna- valley shows strong legibility within itself and with its surroundings. The factors weakening legibility derive from limitations of management for self- sufficiency, such as the reseeding of grasslands, firewood production in mono species acacia forests and fields not yet divided by ecological elements. Another factor weakening landscape legibility derives from the not traditional religion of Krishna- consciousness in Hungary, the effect the Krishna- conscious community has on the landscape is unusual and different from landscape management in the region. This discrepancy is however well compensated by conscious agroecological and landscape management that aims at embedding Krishna- valley in the wider natural and historical context of the region.

Table 23. Landscape legibility based on the four different types of coherences

Weak points	Coherence	Strong points
• Large areas of reseeded grasslands with homogenous species composition  • Single species forests of invasive Acacia trees • Low stage of development for plants in the botanical garden and new plantation, creating a monotonous landscape	**Vertical**	• Agroecological management adapted to local conditions • Large agrobiodiversity of crops and native species • Natural and semi- natural grasslands with native flora • Presence of native flora and fauna in managed habitats • Forests, tree borders, parks and wet biotopes creating a mosaic like landscape structure  Artifical lake with a diverse flora of wet habitats
• Lower field size, more mosaic like landscape structure and lower intensity management than surrounding area	**Horizontal**	• Presence of crop species typical to the region • Presence of native flora and fauna  *Alnus glutinosa,* a typical tree species of riverine woodlands in Somogy • Coherent ecological network • Presence of special places in the landscape in form of sanctuaries  Sanctuary at a river side
• Freshly seeded grasslands show no variety in color and shape during seasonal changes  First year grassland	**Seasonal**	• A wide variety of colors and shapes in the landscape typical of the season both in natural and agricultural components  Autumn in the flower garden
• Historical structures not present in the area of Krishna-valley • Architecture of Krishna- temple and barn does not resemble local traditions	**Historical**	• Consciously managed historical mementos, such as the silk road or old group of trees • Agricultural production historically relevant by use of traditional varieties and management practices

3.4.4. Discussion

Rotation design

While cereals and oil crops deplete the soil of nutrients because the crop products are removed, leguminous crops help to add nutrients to the soil by nitrogen fixation or increase soil organic matter by incorporating nutrients, reducing runoff (Abawi, 2000). The leguminous crop most widely used in Krishna- valley is alfalfa, which is an important crop in hay production, but at times it is also used as a green manure. To maximize the benefit from leguminous nitrogen fixation and to avoid leeching of nitrogen to the soil, manure is applied to cereals that do not follow leguminous crops. This way leguminous nitrogen and nitrogen from manure is more evenly distributed. With seed mixtures including leguminous species, such as clover, grassland production also contributes to atmospheric nitrogen fixation. Non-leguminous green manure crops used in plough field production, such as phacelia and sudan grass also contribute to pest suppression by providing poor host to main crop pests and to weed suppression by phytotoxic effects that hinder weed seed germination (Abawi, 2000; Dhima, 2009).

Table 24. shows a comparison between the share of areas between different crop types and the Hungarian organic sector. The statistics available from the European Commission do not include the share of green manure crops, so these were excluded from the comparison and the percentage of shares in Krishna- valley was corrected accordingly. Compared to the Hungarian organic sector, the share of grassland production in over represented in Krishna- valley by 20%. This can be accounted to the central role that cattle play in *vedic* agriculture. Accordingly, share in areas for cereals, oil seeds and permanent crops, such as fruits is about half for these crops of the Hungarian average (European Commission, 2013).

Table 24.. Share of area by crop type of total production areas in Krishna- valley and the Hungarian organic sector. (European Commission, 2013).

Crop type	Production Area in Krishna valley (ha)	Corrected share of area (%)	Share in the Hungarian organic sector (%)
Cereals	10,7	10%	19%
Oil seeds	3,2	3%	6%
Vegetables	1,3	1%	1%
Grassland	75,8	72%	52%
Green fodder	12,6	12%	13%
Permanent crops	2,1	2%	5%

Crop yields

Table 25. shows the yield comparison between major cereal crops, sunflower and certain vegetable crops in Krishna- valley, in the conventional agricultural sector in Hungary and estimated organic reference yields (KSH, 2013b; Offerman and Nieberg, 2000). Offerman and Nieberg reported in 2000 that yields for cereal production in organic agriculture are between 60- 70% of those in conventional production. In Krishna- valley, yields of wheat, barley and oats exceed the estimated organic reference yields by 15- 69% and in the case of barley, yields in Krishna valley even exceed conventional yields by 36%. Hay yields produced from alfalfa match exactly the average conventional yields. In this case no organic reference yields were available. These results show that management practices and crop rotation design are successful in maintaining good levels of yields in Krishna- valley in case of plough field production. It is also important to point out that from these results, no negative effect on yields from oxen- powered management can be established. On the other hand,

vegetable yields are substantially lower than those of conventional production and do not approach reference yields in organic production. This can probably be accounted to the low mechanization level of vegetable production compared to large scale conventional and organic production, but also to the limitations for labor in crop management that can have an effect on weed infestation, negatively affecting yields.

Table 25. Yield comparison between major cereal crops, sunflower and certain vegetable crops in Krishna- valley, in the conventional agricultural sector in Hungary and estimated organic reference yields (KSH, 2013b; Offerman and Nieberg, 2000).

Crop	Yield in Krishna valley in 2012 (t/ha)	Conventional yields in Hungary in 2012 (t/ha)	Krishna- valley yields as % of conventional yields	Organic reference yields as % of conventional production
Wheat	3	3,7	81%	66%
Barley	3	2,2	136%	67%
Oats	2,2	2,5	88%	73%
Sunflower	1,5	2,1	71%	65%
Hay (alfalfa)	3,4	3,4	100%	n.a.
Potato	8,6	20	43%	69%
Carrot	11	31,5	35%	90%
Parsley root	6	11,6	52%	90%

Animal husbandry

Although not organically certified, the cattle component is also managed in Krishna- valley in the spirit of organic agriculture and even more, in the spiritual devotion towards cows in Krishna- consciousness. Animals are fed exclusively on on- farm produced grass, hay and concentrate, thus meeting the requirements of organic standards that do not allow for genetically modified grain, chemically treated feedstuff or animal by products, except for milk . Also in the field of animal well being, Krishna- valley performs well by providing an environment for the animals where they can express their natural behavior, for example grazing, suckling of milk by young calves or access to natural herbs (Blair, 2011, pp. 3-8). By providing for the animals until their natural deaths, the organic standards for animal well- being are even exceeded.

The animal component shows three weak points, firstly that of artificial insemination, which is allowed in organic practices, however, limits the animals in their natural mating behavior. Artificial insemination is used to maintain genetic variability of the herd, avoiding inbreed and improving genetic lines by purchasing inseminating material from well performing bulls. However, to support natural mating behaviour and reduce reliance on external inputs is could be advisable to acquire more bulls for the herd. This is limited by the fact, that once a genetic line has been exhausted within the herd, bulls can not be exchanged or sold, because of the cow protection activity in Krishna- valley. For this reason, resources and labour could be limiting to acquire an adequate number of bulls and provide for them until their natural deaths.

The second weak point is the nose- ring applied to the oxen at a young age, which can be considered against the organic principle of not mutilating animals. The use of oxen for traction in field works requires the nose ring for controlling the animals during work and is a traditional process that, according to Ghanasjama das does not hurt the animals after the ring has been put in. The third weak point is the feed balance of the animals showing a large excess of protein. It is important to point out, that the excess protein in the feed balance could be the result of a fault in the modelling process of FarmDESIGN, therefor further research would be needed to assess the feed balance. This excess protein in the diet does not reflect negatively in the well- being if the animals, however, it can result in lower conception rate of heifers, as showed by Canfield (1990). Excess protein is not efficiently utilized in the rumen, which can lead to extra energy needed for metabolism in the liver, possibly leading to milk-loss (Muller, 2003). To balance the diet for protein, one advisable solution would be to introduce cereal straw into the diet of the animals, as it contains 30-40 grams of CP/ DM kg against the CP content of 80-120 grams of CP/DM kg of alfalfa hay (Blair, 2011, p.188). Muller suggests balancing the diet by providing grain concentrates high in readily fermentable carbohydrates to neutralize the ammonia released from the excess protein (Muller, 2003). As shown in the optimization process in Chapter 3.4.2. to balance both grazing period and non-grazing period CP inputs and requirements, it would be advisable that in general, a higher proportion of energy should come from cereals, in the grazing period hay from alfalfa supplemented with straw, and in the stable period, hay from grass should be more dominant in the diet. This modification can be performed even without altering crop areas.

Comparing horse- draught technology of the early 20th century and tractor traction, Rydberg and Jansen found that while 60% of inputs needed for animal traction were renewable and locally available, only 9% of the inputs were renewable for the tractor. While animal traction relied mostly on local resources, tractor traction requires high- technology inputs of non- local, non- renewable resources. The highest ratio of input required for animal traction was found to be labor and services for the animals. Compared to tractor based traction, animal traction also provides other beneficial services to the farming system, such as manure, leather and meat (Rydberg and Jansen, 2002). Using animal traction in Krishna-valley is a good alternative for minimizing reliance on external inputs, although its use is limited by labour availability.

Protecting long term soil fertility

Maintaining long term fertility of the soil in the agricultural system of Krishna- valley is essential for developing long term sustainability of food- self- sufficiency. As shown in the diagnosis, chemical fertility has a positive balance for nitrogen, but a negative balance for carbon, phosphorus and potassium. The negative balance for C, P and K cannot be compensated even if removing crop exports and altering crop areas and crop product destination. Soil organic matter and nitrogen balances on the other hand could be substantially increased by altering crop rotations to include more cereals, alfalfa and less grassland. These results are in accordance with the findings of Gosling and Shepherd (2004), which show, that organic P and K balances of organic systems rely on the inputs of previous conventional systems, for which the soil is mined in lack of external inputs. Although mineral weathering and catch crops could make up for some of the outputs, it would be advisable to monitor soil P and K reserves over the years and interfere with external inputs if necessary (Shepherd, 2004).

The absence of mineral fertilizers in organic farming systems results in a higher emphasis on preserving SOM reserves. Higher reserves of SOM result in better plant nutrition, enhanced water absorption of soils, reduced runoff and erosion. Adaptation to climate change is enabled through higher water availability during dry periods, on the long run, contributing to the resistance of the system. While single measures are less effective, the problem of climate change should be approached through complex solutions including the whole plant- animal system. A complex approach requires risk- distribution among components of the agroecosystem, such as cultivating a wide range of species and varieties, applying wide crop rotations, soil cover to protect against erosion and reduced tillage (IFOAM, 2010). The SOM balance of the system could not be assessed accurately, since there is no data available about yearly SOM degradation. Assuming 1% yearly degradation, the farming system is in balance for SOM levels. The wide rotation, the high species and variety diversity of crops, the use of green manure crops all play an important role is preserving

SOM, however, improvements could be carried out to make adaptation to climate change stronger, which is a central issue of agricultural production in Krishna- valley. From the optimization process it seems that a higher ratio of alfalfa and multi- purpose green manure crops would be advisable. As labour is a strongly limiting factor of production and tilling is the most labour intensive task, experiments with low or no- till methods could both lower labour requirements and enhance SOM balances.

Social and agricultural sustainability in the light of permaculture principles

Hungarian ecovillages are either formed in depopulated villages or as part of an already existing community. Krishna- valley is somewhat different, having been formed besides, and not as part of an already existing village community. While the criteria for moving to an ecovillage is usually defined as the acceptance of common rules and principles, Krishna- valley, being a religious community, expects a long spiritual preparation before joining the community (Cake- Baly, 2009). Religion plays an important role in Krishna-valley to let go of material needs and facilitate transmission to ecovillage living, form strong communities and recruit new members. It is probably due to this reason why Krishna- valley has emerged to be the largest ecovillage of Hungary and the only one with a growing population and its own elementary school. Although there is no scientific data available for the degree of food self- sufficiency in Hungarian or European ecovillages, estimations show that Krishna- valley is one of the two food self- sufficient ecovillages in Hungary, the other being Galgahévíz, supporting a community of 15 people compared to 130 in Krishna- valley (Cake- Baly, 2009). These comparisons show, that not only is Krishna- valley the largest ecovillage in Hungary, but probably also most successful one in meeting the goals of an eco-community.

Trainer argues, that the limits to economic growth are set by limited resources, especially arable cropland. As growth emerges, wealth is concentrated in the hands of few, while ecological resources are exploited and wealth is distributed more and more unequally. Trainer identifies the most important component of building sustainability to be self-sufficient communities. With strong communities, it is possible to compensate for lower access to material goods. A sustainable society according to this theory includes 1.) Materially simple lifestyles, low resource use and low income 2.) Small scale and highly self- sufficient local economies 3.)Cooperative systems for sharing of commons and development of participatory democracy, decentralization of government 4.)Sufficiency in consumption by accepting simpler lifestyles (Trainer, 1997). Haraldsson et. al. also argue that sustainable, or ecological living emerges from shift in social perception and cooperation between members of the community. They identify housing and food access as the two factors contributing the most to the ecological footprint, thus being the most important when meeting the needs of the community without exploiting natural resources (Haraldsson et. al, 2001). The

Ethical basis of permaculture calls for the care of the earth and people by providing access to those resources that are necessary for their survival and well- being. As argued by Trainer (1997), permaculture also emphasizes setting limits to the human population and consumption by reducing material needs. In this context, natural systems should only be used to the extent of necessity. The rule of conservative use calls for reducing waste, replacing lost minerals, energy accounting and assessing long term biological effects of changes in the system. These rules are in accordance with the sustainability approach of Pretty (2008) and Trainer (1997), but the principles of permaculture go into more detail for designing permanent- or sustainable systems, as shown in Table 26.

Table 26. Key principles of agricultural and social sustainability, permaculture and reflection of these principles in Krishna- valley

Key principles of agricultural and social sustainability as identified by Pretty (2008) and Trainer (1997)	**Key principles of permaculture as described by Mollison (1998)**	***Socio- spiritual guidelines*, if these do not apply, practical reflection of sustainability and permaculture principles**
Integration of biological and environmental processes into agricultural production	Working with nature, forces and processes	*Nature and humans considered as part of a cosmic order, sense of interconnectedness with nature*
	Planning for succession process of components	Long term plans for development of the system, creating semi-natural landscapes
	Using edges as productive elements of the system	Tree borders and ditches used as bufferzones for protecting crops and enhancing biodiversity
	Placing elements in a way that serves the needs and accepts the products of other elements	Multifunctionality of crops and landscapes
	Catching and storing energy, collecting resources when they are abundant and using them when they are scarce	Storing of crop products for winter and possible scarcity of resources
Minimizing dependence on non-renewable resources	Using renewable resources, reducing waste Self- regulation:	*Devotional service requiring independence from the outside world*
Improving self- reliance by building on local knowledge	Using and responding to change	Knowledge sharing in ecovillage communities and building knowledge base by educating members of the community, adaptation to change by experimenting with new technologies
Building on communities		Strong sense of community through spiritual connectedness of members
Raising multifunctionality of the agricultural system	Working with guilds: Species assembly that provides many benefits for resource production and self- management	Wide use of multifunctional agroecological components, multifunctional crops and landscapes
Using locally adapted technologies		Use of locally adapted plant and animal varieties, on farm developed technologies
Materially simple lifestyles, low resource use, sufficiency in consumption	Using renewable resources, reducing waste	*Spiritual guidelines imply a materialistically simple lifestyle*
Small scale local economies		Local currency, reliance on local labour, but also need for external labour
Cooperative systems for sharing of commons, decentralized government		Cooperative system for distributing goods and services, but a centralized government

Certain sustainability and permaculture principles show a direct overlap with the social and spiritual demands of the Krishna- valley community. Relying on biological and environmental processes was identified as a key social demand towards agriculture that results from the vedic worldview of humans and nature being part of a cosmic order. The devotional religious service of members requires independence from the outside world and a materially simple lifestyle, both of which are reflected in the sustainability principles as minimizing reliance on external resources and reducing resource use. The details of the practices connected to these principles will be discussed in the Chapter 4.1.

The permaculture principle of planning for succession in the agricultural production in reflected in the practices of Krishna- valley mostly in woodland, and in a more general sense, in EI management. Semi- natural habitats are restored or created, which allows for natural flora and fauna to return to the landscape. These areas are used more extensively, for grazing animals or firewood. Using edges in a productive way is present in the case of tree borders, which are used for crop protection, erosion control, habitat for natural enemies and shade for grazing animals. Edges are also present on the river and lake banks, these riverine habitats are primarily used for hosting natural flora and fauna, but they serve also as part of forming a harmonious landscape for recreation. Catching and storing energy is an important aspect of self- sufficiency and avoiding risks of unforeseeable climatic conditions. Cereals and hay for human and animal consumption are stored in a quantity adequate for 1-2 years, also vegetables and fruits are preserved for winter consumption.

Climatic change was identified as one of the most pressing problems affecting agricultural production in Krishna- valley. Adaptation to rhapsodic climatic conditions of extremely dry and extremely wet periods is only made possible through crop diversity that helps distribute the risk of not having any yields at all. New technologies are also used to enhance growing conditions especially in vegetable production. The input of new technologies however creates a trade- off between adapting to change and reducing reliance on external resources. Adaptation to change is also enabled through knowledge sharing in ecovillage communities and building knowledge base by educating members of the community. These actions however are only responses to change, using it would require climatic change to be unidirectional with clear tendencies, which is currently not the case in Hungary.

The aspect of social sustainability can be assessed as to which extent the society builds on communities, uses locally adapted technologies, has small scale economies, a materialistically simple lifestyle, a cooperative system for sharing common goods and a decentralized government (Trainer, 1997) In Krishna- valley, there is a strong sense of community that is the result of the strong sense of sharing religious values and worldview between the members of the community. The system is secured in a way, that once someone does not share does values, they can leave the community and return to civilian life. From this aspect, the system will be sustainable as long as enough members are devoted enough to live in the community, so far, the raising number of inhabitants in and around Krishna- valley show that this is the case. Locally adapted technologies are developed by members of the community with the help of experts- these include the cellar system for storing products, sun-drying devices for drying fruit, tractor machinery adapted to oxen work and a capstan that can be used for various mechanical tasks. This kind of local innovation makes it possible, that production of goods is adapted to local conditions as much as possible. The small scale economy is also present in Krishna- valley in the form of the local currency and using local labour to the highest extent possible. However, certain technologies and goods require external inputs, which lowers the self- sufficiency, thus the sustainability of the community. There is a cooperative system present, since goods and services are distributed evenly and members of the community work according to their skills to serve the community best. The criteria of social sustainability for a decentralized, grassroots government is however not present in Krishna- valley.

Compared to the average population of Hungary, we can assume that the community of Krishna- valley leads a more sustainable lifestyle, which can be mostly accounted to the sound use of agroecological principles in agricultural production and ecological infrastructure management and a materialistically simple lifestyle combined with a strong sense of community.

4. Synthesis

This chapter will provide an integration of the different system components and management methods in the social and spiritual context. The aim is to provide an overview of interrelation between social and biophysical components of the agroecosystem and to analyze compliance of the agroecosystem composition and management with agroecological principles, social and spiritual demands. The end of the synthesis will result in a SWOT analysis to compare positive and negative attributes that Krishna- valley faces on the internal and external level.

4.1. Interrelations between social and biophysical components of the agroecosystem

4.1.1. Meeting social and spiritual demands

As discussed in Chapter 3.1.6 and presented in Table 3., agricultural production and managing the agroecosystem has to be in strong correlation with spiritual guidelines and social demands of the community. The direction of development is Krishna- valley is aimed at creating a completely self- sufficient community for food and firewood that is sustainable on the long term and both socially and spiritually acceptable. Table 27. gives an overview in which way the social and spiritual demands and expectations of the community are met or disregarded in agricultural production.

Table 27. Meeting social and spiritual demands on agriculture

Social and spiritual implications, demands and expectations	**Implication for agriculture**	**Practical implementation for agriculture and EIM**	**Discrepancy between demands and implementation**
Nature and humans considered as part of a cosmic order, sense of interconnectedness with nature	Understanding and building on natural processes	Applying green and animal manures	Mining of soil phosphorus and potassium
		Multifunctional crop rotations	
		Crop protection with natural remedies	
		Using crops and varieties adapted to local conditions	Growing of vegetable crops not adapted to climatic conditions in Hungary relying on modern technologies
		Enhancing natural processes by EIM	Environmental context limiting

		Reliance on natural processes for sewage treatment	
		Reliance on natural processes for health care of the community by honey and wild herbs	External medicine for humans, cows and honeybees in case of serious health threats
Ahimsa and *Karma* implying a vegetarian lifestyle, an aggression free society	Agriculture has to support a lactovegetarian lifestyle while avoiding pollution and hurting other living things	Production of cereals, vegetables, fruits and nuts, but no meat products	Traditional vedic food crops do not always perform well
		Management planning has to adapt to the whole life cycle of cattle	
		Production of milk and milk products	
		No artificial fertilizers or pesticides are used, plant protection and nutrient management relies on natural processes	
Devotional service requiring independence from the outside world	Agriculture should be independent from external resources	Agricultural production relies to a high extent on human and animal labor within the community	Reliance on external labor for labor intensive production practices Reliance on gasoline based traction due to labor limitations
		Developing local knowledge and genetic base for development	Reliance on technological assets for agricultural management
		Own propagation of vegetable and arable crops	Dependence on external resources for propagation of grasslands and flower production
		Reliance on internal nutrient cycling (animal and green manures) for nutrient management	Mining non-renewable sources of soil phosphorus and potassium
		Storage of food products in case of external factors negatively influencing production	
Spiritual guidelines imply a materialistically simple lifestyle	Agriculture has to support all basic needs, but no luxuries	Specified labor suited to ones own skills	Limitations of labor availability
		Highly diversified agricultural production of food products, that support need for cereals, fruits, vegetable, nuts and oils	Reliance on external sources of firewood, clothing

	Highly diversified agricultural system with specific tasks and management practices	Limitations of specific labor availably
	Continuous supply of food products requires well planned rotations, variety use and processing	

In Krishna- consciousness, nature and humans are considered all part of a cosmic order that creates a sense of interconnectedness of the inhabitants with nature. This sense of interconnectedness requires that agricultural production and EIM consider natural processes and build on these to a large extent. This guideline is also in accordance with the principle of using biological and environmental processes in sustainability and permaculture theories as discussed in Chapter… In general, most aspects of agroecosystem setup and management are adapted to the geographical and the natural setting of the area. In agricultural practice this worldview results in applying ecological practices for nutrient management, pest control and yield enhancement. Nutrient management relies on internal nutrient cycles, minimizing losses by using multifunctional crops, such as cereals for grain and straw and applying green and animal manures. Multifunctional crop rotations in plough field and vegetable production aim to enhance natural crop protection by creating unfavourable conditions for pests and weeds, and with a high ratio of green manure crops they also contribute to nutrient management. While in plough field and fruit production a large number of locally adapted crop varieties are present, the vegetable component also relies on modern technologies for growing specific crops. As discussed in Chapter 3.4.1., depending on the level of SOM degradation, the agricultural system of Krishna- valley is possibly lowering SOM levels and certainly depleting soil reserves of phosphorus and potassium. In the long term, these practices could lead to lowering of crop yields due to nutrient deficiency. The worldview of Krishna- consciousness also has an effect on EIM, which aims to enhance natural processes for the productivity of agriculture, but also for the wellbeing of the inhabitants. The community relies to a large extent on natural processes, such as sewage treatment in a root- zone system, natural remedies for health care of humans and cattle, firewood and clean drinking water. However, this system cannot provide at this time protection of humans, cattle and honeybees for more serious health problems, in which case reliance on modern medication, such as antibiotics is needed. The EIM practices performed in Krishna- valley also reflect these principles by providing habitat for a wide diversity of species.

The principles of *Ahimsa* and *Karma* imply a generally aggression free society which requires agriculture to support a lacto-vegetarian lifestyle without and to do no harm to other living things in nature. In Krishna- valley, a full self supply of cereals, vegetables, fruits, nuts, honey and milk products meets all needs of the lactovegetarian lifestyle. As the cattle plays a central role in the agricultural system without being killed off for meat, the planning of long-term management adapts to the lifecycle of animals. Since production of feed, agricultural management with oxen power and human labor required are strongly correlated, these factors all play a central role in expanding production. *Ahimsa* and *Karma* are also in strong correlation with natural farming practices, as they limit the use of possibly harmful compounds for pest and nutrient management. This again plays a role in relying on natural processes for nutrient and pest management and the lack of pesticides and artificial fertilizers in agricultural production. There were no practices or components identified in the agroecological system that disregard the principles of *Ahimsa* and *Karma,* showing that these principles are of central importance in the society of Krishna- valley.

As the spiritual guidelines require devotional spiritual service of the inhabitants, it is a general aim for the community to be independent from external resources; this way no time has to spent acquiring money to buy goods. In practice, this principle reflects most strongly in the reliance on human and animal labor for agriculture. The labor-intensive system on one hand allows for employment for a large number of members of the community and also reflects in crop choice and management being highly labor intensive. At the moment however the self- supply of vegetable crops still relies on external labor. While self- supply of cereals is currently managed with oxen labor, certain components of plough field production require tractor power, thus raising dependence on external resources and conflicting with the principle of not polluting the environment. While self- supply of food does not rely on external resources except for labor, the firewood production capacity of Krishna- valley is not enough to cover the needs of the community, also raising dependence on external resources. Clothing and building materials can currently not be provided by the agricultural system at all, for these, expansion of sylvicultural production and introduction of fiber crops into the production would be necessary. The highly diversified agricultural system has specific tasks and management practices that require specified labor. Currently, the availability of specified labor within the community limits expansion of the herd, plough field management and vegetable production. The continuous supply of food throughout the year necessitates well-planned management of agricultural production and processing. In practice, this reflects in the requirement of many labor hours for farm management and administration.

4.1.2. Flow of goods and services between social and biophysical components

Figure 16. shows flows of products and services between social and biophysical components of the agroecosystem, also indicating external inputs and outputs, while Figure 17. provides a systemic overview of these processes. On the one hand, agricultural and ecological products and services need to meet the social and spiritual requirements of the community, while on the other hand they also serve the purpose to meet requirements of the agricultural system itself. It can be seen in the Figure 12, that all needs of the community and the agroecosystem are met by several different processes and products, originating from several different components, giving the picture of a widely multifunctional composition of components. Although self- sufficient to the fullest in terms of food, exports are needed both for meeting the material and social needs of the community and for producing crops. In case the scale of production exceed needs of the community, products are exported, while certain services provided by the ecological infrastructure provide positive externalities to the surrounding area.

The needs of food and fiber are met not only by agricultural components, such as animal husbandry, plough field management, fruit and vegetable production, but also supplemented by wild plants provided by the ecological infrastructure. Currently, fiber is a resource that is not provided within the agroecological system and needs to be sourced externally. As *vedic* medicine relies mostly on prevention and treatment with natural remedies, the wild herbs are also used to meet the requirement of healthcare, along with apiary products and ghee. Only in the case of serious illness, such as infections are medicinal products, like antibiotics, imported. Fuel is needed for heating and lighting in the households, the needs are met by firewood for heating and plant based oils and beeswax for lighting. As the forest area is currently too small, the community relies on external inputs for firewood. Processes that minimize reliance on external inputs support the social demand for self- sufficiency for food, healthcare, fuel, and aims for long-term sustainability. These processes include animal traction provided by the oxen, production of storable products to be used in case of extreme conditions, sewage treatment by natural processes and a general system stability that relies on the processes of the ecological infrastructure. The spiritual needs of the community are supported by the action of cow protection within the village, the availability of organically produced fruits and nuts for preparing *prasadam* meals and temple decorations produced in the flower garden. The ecological infrastructure, and generally the agroecological practices support the sense on harmony with nature, while the landscape provides a venue for meditation. To enable long term self- reliance of the system, the community relies on building up knowledge about management of the agroecosystem. This knowledge generation then also contributes to being a center of information about sustainable living.

Components of the agroecosystem also directly support each other with products and services, thus indirectly contributing to the independence on external resources on the system level. Animal husbandry requires fodder and bedding that is provided by plough field and grassland production, while disease prevention relies on herbs eaten by the animals or in form of *vedic* medicinal preparations, both of which are sourced from the ecological infrastructure. Curative medicine can rely either on *vedic* medicine, or in more serious cases, on modern medicine from external sources. One component of herd management is housing, which is made possible through the input of building materials sourced externally. Crop management relies also on internal processes supplemented with external inputs. For nutrient supply, internal resources of animal and green manure are used among management practices that minimize nutrient losses, such as mulching and a well-designed crop rotation. Externally sourced mineral fertilizers are used only on a low scale in vegetable production. Irrigation, pest management and general crop protection relies on the ecological infrastructure for water, biodiversity of natural enemies of pests, and shelterbelts preventing deflation and erosion. Securing yields in vegetable production relies on certain inputs for infrastructure from external sources, such as building materials for the greenhouses, the drip irrigation system and organically certified pesticides and plant fortifiers. To lower labor needs, production of vegetable and plough field crops makes use of external inputs if machinery and gasoline, while the low availability of labor within the community also makes external labor necessary. It is important to point out, that while oxen labor is sufficient for producing cereals and oil crops for the community, gasoline based traction is only used in management of crops for sales. The ecological infrastructure benefits from the nutrient distribution allowed by manure and mulch application in different components of the agroecosystem. The high crop diversity generally displayed in agriculture also benefits the general agrobiodiversity of the system, thus contributing to system stability. While bees can provide pollination services also for wild plants, these serve as alternative food source in time when no other cultivated pollen sources are present.

4.2. Aspects of self- sufficiency

As discussed in the previous chapter, internal cycles of products and services are capable of meeting certain aspects of self- sufficiency, while external inputs are needed to provide goods for material needs and supplement internal processes. To assess these aspects of internal flows and external inputs, products, services and inputs can be can be typified by different features of needs and timeframe. Flow of products and services is displayed in Figure 16.

Direct needs for survival on the short term include food, water, heating and healthcare. While food and water are both internally sourced, currently the community relies on external inputs of firewood. Preventive methods for human, crop and animal health rely on internal sources of herbs, manure and fortification, while external sources are only used as curative methods. Water and hygiene relies on internal processes of water supply and sewage treatment. Basic material needs also include building and clothing, at this time these needs cannot be met within the production system

Needs other than those of daily survival include optimizing growing conditions, lowering labor needs while providing employment, creating economic income, meeting spiritual demands and securing independence from external resources on the long term. Indirectly, external sources of genetic materials, organic pesticides, mineral fertilizers and building materials for infrastructure contribute to food security by raising crop diversity and optimizing growing conditions for higher yields. Externally sourced machinery allows for lowering labor demand of management practices, thus enabling the production of marketable products. The production of goods for income generation require gasoline based traction, thus requiring external fuel. On the mid time scale, food security in case of extreme events is provided by storage of crop products. Securing production on the long term to raise independence requires the system to be adapted to climate, geographical and natural qualities. This long- term aim is met by one-time external inputs of genetic material, infrastructural improvements and a continuous input of labor and knowledge in management of the agroecosystem.

Products and services can also be grouped by the frequency of their input. One time external inputs include building materials, machinery, initial propagation materials, while gasoline, organic pesticides, mineral fertilizers and curative medicine are inputs requiring input continuously. There are certain inputs that are not necessary, but have an effect on sustaining quality, such as the renewal of cereal seed- stock every 4-5 years. The internal flow of goods and services, such as management, nutrients, firewood, water, crop and animal protection also require continuous input.

Trade- offs between needs and the reliance on external inputs can be identified in case of labor, land and optimizing growing conditions for raising crop diversity, quality and yield. Certain externally sourced technologies are too valuable in reducing labor and raising production levels that their exclusion could actually result in lower levels of self- sufficiency. These technologies include machinery for plough field production with the oxen and building materials for the greenhouses and storage facilities. In case of labor management, a tradeoff can be identified between the labor availability for animal fodder production and cereal production for human consumption. Not only labor, but also land- availability presents a tradeoff directly between food production, herd size and firewood production and indirectly affecting population size of the community.

System development shows a direction of minimizing dependence on external material inputs. The direction of development for Krishna- valley is to raise the population to 300, raise herd size to100 animals, raise firewood production to 100 hectares and be completely self- sufficient for food, oil, clothing and building materials. Based on the qualities of inputs discussed above, it can be hypothesized that for agriculture these developments would mean lower variety and production level of crops due to non- renewable genetic stock and lack of infrastructural improvement, higher labour demand and specialization level for management to meet all basic needs without gasoline and organic pesticides and lower scale of marketable products due to extension of firewood and grassland production and the strong labour limitations.

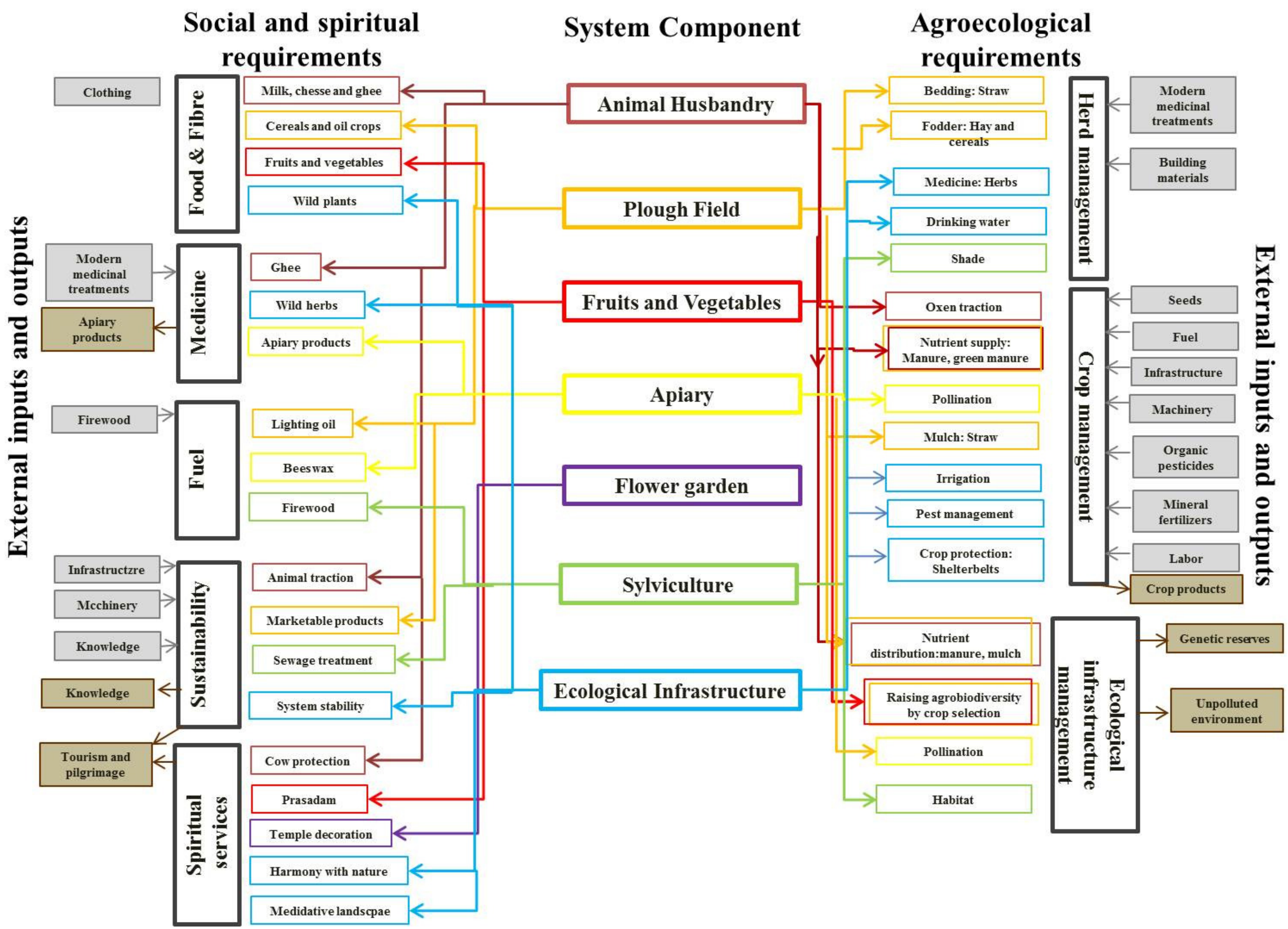


Figure 16. Flows of products and services between social and biophysical components of the agroecosystem and external sources in order to meet social, spiritual and agroecological requirements.

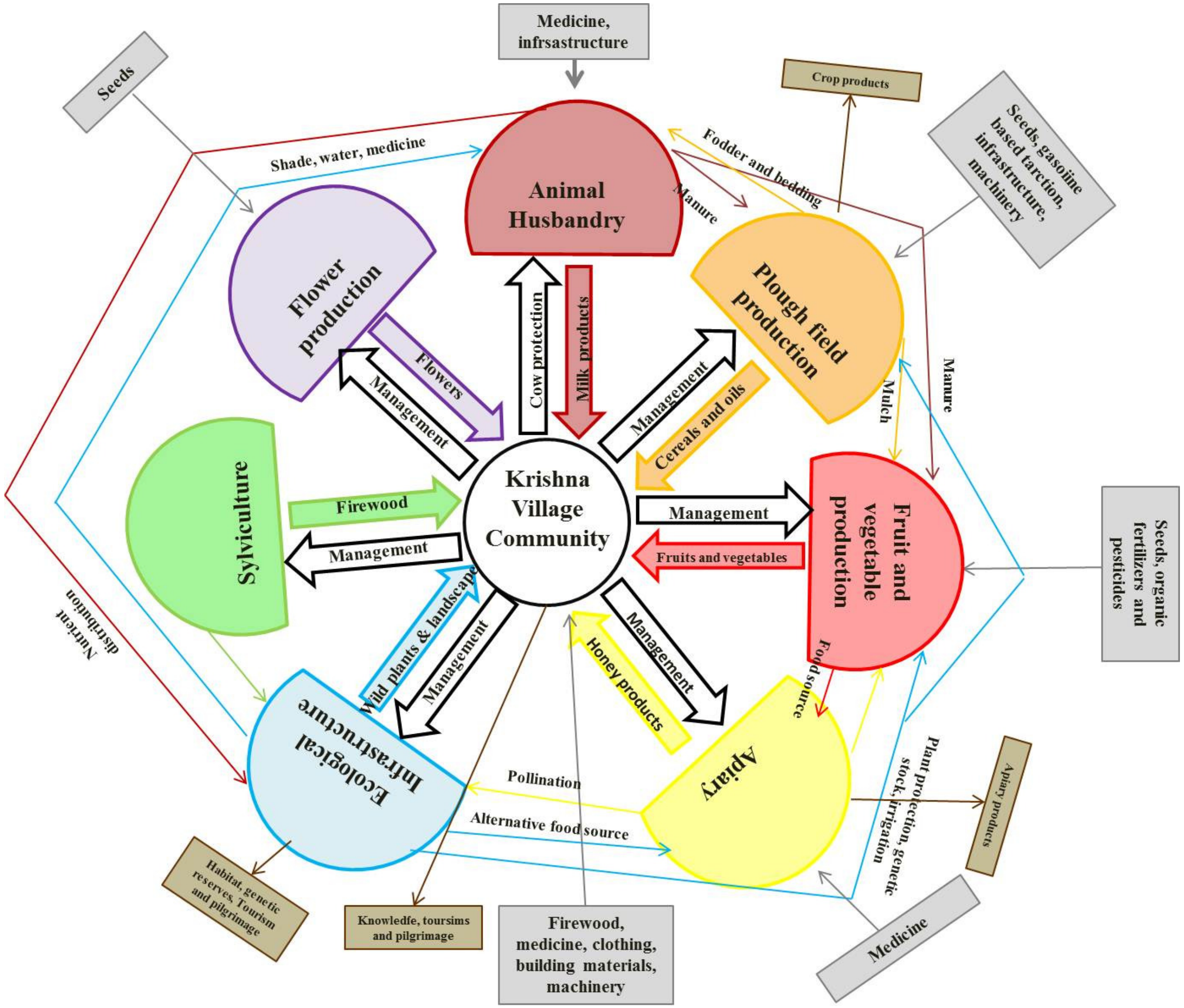


Figure 17. Systematic overview of the product and service flow between social and biophysical components of the agroecosystem, external sources and destinations

4.3. SWOT analysis

In the previous chapters productive and ecological farm performance were analyzed among with interrelations between social and biophysical components of the agroecosystem; the SWOT analysis serves the purpose of highlighting the internal and external, positive and negative attributes affecting the farming activity in Krishna- valley. The SWOT analysis can serve as a basis for future development of the farming system and ecological infrastructure management. Results are summarized in Table 26.

Table 28. SWOT analysis of the agoecological system of Krishna- valley

STRENTGTHS	WEAKNESSES
• Yields sufficient for organic production methods for cereals and hay • More SOM and nitrogen inputs, than outputs	• Yields low for organic production methods in vegetable production • Mining of soil phosphorus and potassium without inputs, SOM degradation could result in a negative balance
• No artificial fertilizers and conventional pesticides and herbicides, preventive medicine relying on internal resources	• Animal and human treatment, organic amendments, machinery and fuel from external sources
• Full self- sufficiency for cereals, hay, fruits and vegetables	• Reliance on external sources of firewood, clothing, building materials
• Performance in EIM: wood coverage, pest suppression, diversity of habitats, field size index	• Performance in EIM: Homogenous species composition in grasslands and acacia forests
• Landscape providing a meditative venue for the community, strong vertical coherence of the system	• Weak horizontal coherence with the surroundings, weak historical coherence, weak seasonal and vertical coherence in large fields of newly planted grasslands
• Coherence between components of the agricultural production, environmental conditions, social and spiritual demands realized through organic agriculture, reliance on internal labor, adaptation to local conditions, minimizing external inputs	• Enhancing production quality and quantity requires external inputs of organic fertilizers, pesticides, labor, machinery and building materials for infrastructure, • Tradeoffs between labor availability and external inputs of gasoline based traction
• Continuous adaptation to changing conditions with crop variety selection and management practices	• Slow implementation of changes and slow response to changing conditions due to adaptation of management to the lifespan of cattle

OPPORTUNITIES	THREATS
• Overproduction of cereals and hay allows for expansion of herd size, food production • Income generation through sales of crop products and tourism allows for experimentation • Knowledge build up about organic practices and self- sufficiency creates an opportunity for becoming and expanding as a knowledge center • Adaptation to climatic changes by high diversity of crops and storage of resources • Enhancing economical, social and environmental processes in the region • Raise acceptance and create a good image of Krishna- consciousness through a representative self- sufficient community	• Expansion of production limited by land and labor availability • Touristic and pilgrimage activities can pose an environmental threat • Climatic changes threaten stability of the system by creating unforeseeable growing conditions • Infections, epidemics from surrounding agricultural landscape can affect crop and animal health

The productive farm performance and performance in EIM show both strong and weak qualities in the system. While yields are sufficient for organic production in case of cereals and hay, vegetable yields are lower than average organic yields. Management practices in farming result in a positive SOM and nitrogen balance, but if considering SOM degradation and no or very low inputs of phosphorus and potassium, a negative balance could result in lower productivity on the long term. To maintain soil fertility, no artificial fertilizers, pesticides and herbicides are used and preventive healthcare relies on internal sources, but animal and human medicinal treatment, organic amendments, machinery and fuel have to be sourced externally. Ecological infrastructure management performs well in the context of wood coverage, pest suppression capacity and diversity of habitats, but shows negative attributes in large fields and plantations with homogenous species composition.

Chapter 4.1 summarized the interrelation between the Krishna- community, the agricultural components and the ecological infrastructure. From this analysis, the results showed, that on the internal level, the farming system shows a strong coherence between social and spiritual demands of the community and the farming system. Social demands are met with a farming system capable to serve the community's needs for crop and animal products for consumption in accordance with spiritual requirements. The continuous development shows adaptation to permanent geographic and natural conditions by applying organic farming methods and ecological infrastructure management, but also adaptation to changing climatic conditions is influenced by the diversity of crops and natural elements in the system. The weakness of the system for these aspects is, that while Krishna- valley aims to minimize reliance on external inputs, tradeoffs can be observed between enhancing productivity and inputs of labor, modern technologies, building materials and fuel. Although the system is capable to adapt to changing conditions, structural changes can only be implemented slowly due to the necessity to adapt to the lifecycle of cattle.

External opportunities are presented by the overproduction of cereals and hay that allow for expansion of the herd size and food production and the sales of crop products and tourism generates income that leaves room for further experimentation in agricultural production. However, the expansion of production and thus the aim of full self- sufficiency is threatened by the availability of land and labor. While the farming system performs well in terms of not polluting the environment, large scale touristic and pilgrimage activities can pose a threat to the environment within and outside of Krishna-valley, that is not in accordance with spiritual and social demands of the community. The farming system could adapt well to climatic changes due to high system diversity, which poses an opportunity to becoming not only a knowledge center, but also a center of genetic resources for future generations. However, unforeseeable and extreme climatic changes could pose a threat to system stability by changing growing conditions dramatically. While preventive medicine is strongly developed due to traditional *vedic* practices, large scale epidemics could threaten human, animal and crop health. The continuous development of farm management results in knowledge build- up within the community, that allows for becoming a knowledge center for sustainable living. This attribute play an important role in raising levels of acceptance and appreciation for Krishna- consciousness, not only affecting the community of Krishna- valley, but all Krishna- believers in Hungary. The agricultural and touristic activities play a role in enhancing economic and social situation in the region.

5. Conclusion

An agroecological research approach was taken to analyse the productive, socio- economic, ecological and environmental contexts of agricultural production in Krishna- valley. This approach made it possible to reveal interactions between biotic and abiotic components of the agroecosystem, such as nutrient and energy flows and the role of human expectations and activity in these processes. An agricultural landscape is also defined by the context of agricultural production, such the spatial arrangement of non- agricultural landscape elements and their management. These components are an important indicator of agricultural sustainability, as they provide several ecosystem services for agricultural production and human lifestyle. The ecological infrastructure was studied to reveal the effect of natural landscape components and their management methods on the agricultural system. After carrying out the analysis, weaknesses and strengths in the farming system were diagnosed, resulting in implications for improving the farming system and future research.

The spiritual and socio- economic context of Krishna- valley strongly affects the expectations of and demands on agricultural production. The most important spiritual guidelines were identified as forming an aggression free society, leading a life in harmony with nature and a in a materialistically simple manner. These spiritual guidelines result in an agricultural system that is consciously embedded in its environment, uses biological processes to a large extent and is capable for serving most needs of the community for food and fuel. In certain cases a discrepancy was found between the spiritual- social expectations posed towards the agricultural production, such as relying on external inputs for gasoline and labour. Labour availability is a limiting factor in extending agricultural production and population size, since full self- sufficiency for food in the understanding of the community would require relying solely on internal labour of the community and excluding tractor work from plough field management. To reach these goals, population size, herd size and agricultural production need to extend in a harmonized manner, since these three factors are strongly interconnected.

Animal husbandry is in the focus of attention in the agricultural system, because cows are considered holy animals in Krishna- consciousness and are used for their milk and traction power in field works. A specific quality of cattle breeding is that the animals are kept until their natural deaths, which leads to plough field and grassland production planning to be adapted to the lifecycle of animals. Breed selection is based on adaptability to external keeping, capability of oxen to perform field works and milk quantity given by cows. These needs are met with a combination of breeds by an own breeding program. Feed evaluation suggested that the composition of the diet is too high in protein both in the grazing and in the non- grazing periods. Optimization modelling suggests, that the problem could be reduced by introducing a higher ratio of cereals in the diet in general, providing more alfalfa- hay in the grazing period and more grass- hay in the non- grazing period. The animal component shows two other weak point, firstly that of artificial insemination which can be considered to hinder natural mating behaviour of animals and secondly the use of a nose- ring applied to the oxen at a young age, which can be considered against the organic principle of not mutilating animals.

Plough field production provides the community with cereals and legumes and allows for externally marketable products, such as mustard seeds and certain cereals. Grassland production is managed apart from plough field production and has its own rotation. All fieldworks for grassland production and the managing of crops required for food self- sufficiency are carried out by oxen labour, the limiting factor in this case is the availability of labour and oxen power. Management practices and crop rotation design are successful in maintaining good levels of yields in Krishna- valley in case of plough field production and no negative effect on yields from oxen- powered management can be established.

Vegetable production occurs on smaller scales and only serves the needs of the community. To adapt to adverse climatic conditions, the use of modern technology, such as glass greenhouses and drip irrigation is used. Variety selection and the development of the crop rotation is based on the lifestyle and dietary habits of the inhabitants. The aim is to provide a continuous selection of fresh, stored and processed produce throughout the year. Vegetable production is the most labour intensive component of agricultural production that relies on external labour inputs. Comparison with literature revealed that vegetable yields are substantially lower than those of conventional production and do not approach reference yields in organic production.

Fruit production is performed in two orchards that are being developed for extensive production with locally adapted varieties. Fruit production serves the needs of the community for fresh, dried and processed fruits throughout the year. Apiary and flower production are performed on a low scale to meet the community's needs for medicinal apiary products and flowers for church worship.

All agricultural production is performed on 108,7 hectares, the largest constituent being grassland production, requiring over 80% of total agricultural land. The community relies on imports only for foods that are consumed by visitors to Krishna- valley, while animal feeding relies entirely on internal production. Nutrient management in plough field and vegetable production relies solely on manure provided by the herd and green manure crops, supplemented with a low amount of mineral amendments in vegetable production. Pest management in plough field production is only served by crop rotation design, in fruit and vegetable production, natural amendments, such as essential oils and organically certified treatments are also used. Evaluation of SOM balance suggests, that with a estimated SOM degradation of 2% annually, the recent crop rotation results in a negative SOM balance. While N balance is positive, which can be accounted to the presence of N- fixing crops in the rotation, balances of C, P and K are negative. The optimization process shows, that higher areas of cereal, doubled alfalfa production areas and a significant reduction in grassland production, especially for pastures used only for grazing would be advisable for improving nutrient balances for C,N, P and K. Optimization for SOM balance show higher areas of cereals and grass, a higher proportion and amount of straw and grass hay to be used as green manure. Although mineral weathering and catch crops could make up for some of the outputs in P and K balance, it would be advisable to monitor soil P and K reserves over the years and interfere with external inputs if necessary.

EIM plays an important role in Krishna- valley with the goal to nurture natural processes that aid the goal of reaching self- sufficiency. Besides self- sufficiency, the management of the landscape and habitats is also important for spiritual reasons. As a spiritual centre and a site for several holy places, the site needs to be managed in a way that is both natural and aesthetically pleasing. Results of landscape modelling show, that land- use in Krishna- valley is much more diverse than in its approximate surroundings, although forest – coverage does not reach the average of the county. Target value of the Ecological infrastructure index (EII) is 5% , which is exceeded in Krishna- valley, the total area in EIM resulting to 23% by the land- use analysis. Also calculations for field size index (FSI) indicates, that the field sizes are more than optimal for supporting functional biodiversity and the dispersal capacity of natural enemies. The landscape of Krishna- valley shows strong legibility within itself and with its surroundings. The factors weakening legibility derive from limitations of management for self- sufficiency and the not traditional religion of Krishna- consciousness in Hungary, which has an effect of the landscape being unusual and different from landscape management in the region. This discrepancy is compensated by conscious agroecological and landscape management that aims at embedding Krishna- valley in the wider natural and historical context of the region.

The synthesis process showed, that while some qualities of the agroecosystem are in harmony with the social and spiritual expectations, others present a discrepancy. In general, the need for an aggression free society are met well by the agroecological system, while the aim of self- sufficiency is limited by trade- offs between labour, variety of production, land availability, crop yield and quality. Internal cycles of products and services are capable of meeting certain aspects of self-sufficiency, while external inputs are needed to provide goods for material needs and supplement internal processes. Social demands are met with a farming system capable to serve the community's needs for crop and animal products for consumption in accordance with spiritual requirements. The continuous development shows adaptation to permanent geographic and natural conditions by applying organic farming methods and ecological infrastructure management, but also adaptation to changing climatic conditions is influenced by the diversity of crops and natural elements in the system. It was hypothesized that for agriculture development to enhance self- sufficiency would mean lower variety and production level of crops, higher labour demand and specialization level for management and lower scale of marketable products . Results showed, that on the internal level, the farming system shows a strong coherence between social and spiritual demands of the community and the farming system.

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APPENDIX I.
PHOTO GALLERY

1. The cow protection centre

2. Suckling calf

3. Cows before milking in the barn

4. Retired ox

5. Oxen with seeding machine

6. Ploughing with oxen

7. Plough field of the six- component rotation

8. Straw chaffing

	•
 9. Harvesting amaranth by hand	 10. Sheafs of amaranth
 11. Straw bales	 12. Glass greenhouse with winter greens •
 13. Vegetable seed drying in the heated greenhouse •	 14. Orchard with woody shelterbelt

	
15. Storage of vegetables and preserves in the cellar	16. Landscape of Krishna- valley with the elementary school

APPENDIX II.
PARAMETERS AND INPUT VALUES FOR THE FARMDESIGN MODEL

1. LOCATION

KRISHNA VALLEY
Somogyvámos
Somogy County
Hungary

N 46 34' 16"
E 17 40' 45"

2. ENVIRONMENT

	SOIL		
Parameter	**Name**	**Value**	**Unit**
	Soil type	Loess based chernozem	
$F_{OM,s}$	Active org.matter	2,7	~~%~~
k_s	OM degradation	0- 1	%/ year
D	Soil depth	0,5	m
B	Bulk density	1200	kg/m3
U	Texture factor	1	
	Soil pH	6,35	
	Pw value	25	kg/ha/year
	Potassium content	30	mg/ 100 g soil
		720	kg/ ha
Fixation	Lime content	0,47	%
	Non- symbiotic N- fixation	2	kg/ha/year
	CLIMATIC		
N deposition	Nitrogen depostion	15	kg/ha/year
P deposition	Phosphorus depostion	0,2	kg/ha/year
K deposition	Potassium deposition	1	kg/ha/year

	Mean temperature	10	C
	Period with pF<3.5	310	days
	Water available	0	m3/ year

EROSION

$SL_{Erosion}$	Soil eroded	0,01	mm/year
	OM content in erosion	1,5	%
$F_{N,s}$	N content in erosion	6	%
$F_{P,s}$	P content in erosion	0,1	%
$F_{K,s}$	K content in erosion	0,5	%

3. ECONOMICS

-
- **COSTS**

Parameter	Name	Value	Unit
Curr	Currency	Not applicable	HUF
I	Interest rate	Not applicable	%/year
CL	Costs of land	Not applicable	Curr/ha
CG	General costs	Not applicable	Curr
CO	Other animal related costs	Not applicable	Curr
P_{LC}	Casual labor costs	Not applicable	Curr/hour
P_{LR}	Regular labor price	Not applicable	Curr/hour

-
- **LABOUR**

LR_{Farm}	Farm Labour	9130	hours/year
LR_{Herd}	Herd Labour	3416	hours/year
LR_{Input}	Family Labour	27490	hours/year

-
-

4. CROPS

Parameter	Name	Unit
X_c	Symbiotic nitrogen fixation (legumes)	kg/ha/year
$OM_{RootStubble,c}$	Effective organic matter input by crop c	kg/ha/year
h_c	Humification coefficient of crop residue	kg/kg
C_c	Cost for production of the crop	Curr/ha
W_c	Costs for contract work	Curr/ha
S_c	Subsidies for production of the crop	Curr/ha
LR_c	Regular (skilled) labour requirements	hours/ha
LC_c	Casual labour requirement	hours/ha

Crop name	X_c	$OM_{RootStubble,c}$	h_c	LR_c	LC_c	C_c	W_c	S_c
Wheat 1	0	1000	0,2	31	0		Not applicable	
Wheat 2	0	1000	0,2	31	0			
Potato	0	4375	0,2	693	0			
Barley	0	1000	0,2	14	0			
Oats	0	1000	0,2	14	0			
Mustard	0	800	0,2	14	0			
Sunflower	0	500	0,2	34	0			
Sudan grass	0	1000	0,2	14	0			
Phacelia	0	1000	0,2	14	0			
Amaranth	0	1000	0,2	34	0			
Grass (grazing)	35	1100	0,2	0	0			
Grass (cutting)	15	1100	0,2	16	0			
Grass (grazing+ cutting)	25	1100	0,2	8	0			
Carrots	0	3000	0,2	674	1572			
Red beet	0	3750	0,2	204	474			
Parsley root	0	3000	0,2	720	1680			
Pumpkin	0	500	0,2	292	681			
Summer vegetables	0	500	0,2	3640	8573			
Fruits	0	0	0,2	780	143			
Grass (1st year)	35	1100	0,2	8	**0**			
Wheat 3	0	1000	0,2	14	**0**			
Alfalfa 1	300	1100	0,2	32	**0**			
Alfalfa 2	300	1100	0,2	32	**0**			
Alfalfa 3	300	1100	0,2	32	**0**			

5. CROP PRODUCTS

$F_{OG,p}$	Fraction of the amount of crop product p fed to animals that is supplied outside the grazing period	kg/kg
DM_{Bedd}	Use for bedding of animals in the stable	kg DM
FM_p	Yield of fresh material	kg/ha
$F_{DM,p}$	Dry matter content	%
$F_{L,p}$	Losses during feeding to animals	%
$F_{N,p}$	Nitrogen content in dry matter	%
$F_{P,p}$	Phosphorus content in dry matter	%
$F_{K,p}$	Potassium content in dry matter	%
$F_{A,p}$	Ash content in dry matter	%
Sat_p	Feed saturation value	-
Str_p	Feed structure value	-
VEM_p	Energy contents	VEM per kg DM
DVE_p	Protein contents	g DVE/kg DM
P_p	Price of the fresh material	Curr/kg
Calculative parameters		
DMYield	Yield in DM	kg/ha
fracSoil	fraction DM applied to the soil	
fracFeed	fraction DM used as feed	
fracBed	fraction DM used as bedding	

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Crop	Crop product	Area	FM_p	DMYield	fracSoil	DM_{Soil}	fracFeed	DM_{Feed}	$F_{OG,p}$	fracHome	DmHome	fracBED	DM_{Bedd}	Total yield	Total DM yield	$F_{DM,p}$	Used as feed	Used as green m.	Used as bedding	Home cons
Wheat1	Wheat	6	3000	2610	0	0	0,189	2958	0,35	0,22	3445	0	0	18000	15660	87	3400	0	0	3960
	Straw	6	4000	3600	0	0	0,000	0	0	0,00	0	1	21600	24000	21600	90	0	0	24000	0
Potato	Potato	0,35	8600	1978	0	0	0,000	0	0	1,00	690	0	0	3010	692,3	23	0	0	0	0
Barley	Barley	1,4	3000	2610	0	0	0,714	2610	0,35	0,00	0	0	0	4200	3654	87	3000	0	0	0
	Straw	1,4	4000	3600	0	0	0,000	0		0,00	0	1	5040	5600	5040	90	0	0	5600	0
Oats	Oats	1,2	2200	1958	0	0	0,833	1958	0,35	0,00	0	0	0	2640	2349,6	89	2200	0	0	0
	Straw	1,2	4000	3600	0	0	0,000	0	0	0,00	0	1	4800	4800	4320	90	0	0	4800	0
Mustard	Mustard seed	2,55	800	752	0	0	0,000	0	0	0,00	0	0	0	2040	1917,6	94	0	0	0	0
Sunflower	Sunflower seed	0,67	1490	1370,8	0	0	0,000	0	0	1,00	920	0	0	998,3	918,436	92	0	0	0	1000
Lucerne 1.	Hay	5,78	3400	3060	0	0	1,781	31500	0,92	0,00	0	0	0	19652	17686,8	90	35000	0	0	0
Sudan grass	Sudan grass	2,69	1000	160	1	430,4	0,000	0	0	0,00	0	0	0	2690	430,4	16	0	2690	0	0
Phacelia	Phacelia	2,6	1000	170	1	442	0,000	0	0	0,00	0	0	0	2600	442	17	0	2600	0	0
Amaranth	Amaranth	0,38	260	231,4	0	0	0,000	0	0	1,01	89	0	0	98,8	87,932	89	0	0	0	100
Carrot	Carrot	0,2	11000	2750	0	0	0,000	0	0	1,00	550	0	0	2200	550	25	0	0	0	2200
Red beets	Red beets	0,15	10000	1300	0	0	0,000	0	0	1,00	195	0	0	1500	195	13	0	0	0	1500
Parsley root	Parsley root	0,05	6000	1500	0	0	0,000	0	0	1,00	75	0	0	300	75	25	0	0	0	300
Pumpkin	Pumpkin	0,3	25000	5000	0	0	0,000	0	0	0,99	1480	0	0	7500	1500	20	0	0	0	7400
Grass (cutting)	Hay	28	2000	1800	0	0	1,000	50400	0,92	0,00	0	0	0	56000	50400	90	56000	0	0	0
Grass (c+g)	Grass	14	10000	1800	0	0	0,900	25200	0	0,00	0	0	0	140000	28000	20	126000	0	0	0
	Hay	14	1000	900	0	0	1,000	12600	0,92	0,00	0	0	0	14000	12600	90	14000	0	0	0
Grass (grazing)	Grass	27,8	20000	1800	0	0	0,547	60840	0	0,00	0	0	0	556000	111200	20	304200	0	0	0
Grass (new)	Grass	6	10000	2000	1	12000	0,000	0		0,00	0	0	0	60000	12000	20	0	60000	0	0
Summer vegetables	Summer vegetables	0,3	30000	6000	0	0	0,000	0	0	1,00	1800	0	0	9000	1800	20	0	0	0	9000
Fruit	Fruit	2,1	2950	590	0	0	0	0	0	1,00	1240	0	0	6195	1239	20	0	0	0	6200
Alfalfa 2.	Hay	4,5	1700	340	0	0	0	6885	0,92	0,81	5580	0	0	7650	6885	90	7650	0	0	6200
	Green manure	4,5	7650	1530	0	0	0	6885	0	0,18	1240	0	0	34425	6885	20	0	34425	0	6200

6. ANIMALS

Type	Number	Sex (M/F)	Age (years)	Weight (kg)	Hay GP.	Hay Winter	Fodder GP	Fodder Winter	Milk/day (liter)	Hay total (GP)	Hay total (winter)	Concentrate total	Milk total/day	Growth	Bedding	Bedding total	Bedding DM	Labor/ year
Calf	2	M	0-1	100	0	500	0	0	0	0	1000	0	0	1,37	1,2	2,40	1,08	270
Ox (young)	2	M	1-3	600	0	850	0	0	0	0	1700	0	0	0,41	4,05	8,10	3,65	250
Ox (active)	10	M	3-12	900	0	2300	208		0	0	23000	2080	0	0,00	4,05	40,50	3,65	250
Ox (retired)	10	M	12+	900	0	2300	208	209	0	0	23000	4170	0	0,00	4,05	40,50	3,65	250
Bull	1	M	3-12	1000	0	2300	0	0	0	0	2300	0	0	0,00	4,05	4,05	3,65	250
Calf	2	F	0-1	100	0	2300	0	0	0	0	4600	0	0	1,03	1,25	2,50	1,13	270
Cow (Heifer)	2	F	1-3	475	0	2300	0	0	0	0	4600	0	0	0,31	1,2	2,40	1,08	230
Cow (milking)	4	F	3-12	700	2000	2300	208		10	8000	9200	832	60	0,00	1,25	5,00	1,13	340
Cow (non- milking)	5	F	3-12	700	0	2300	0	0	4	0	11500	0	20	0,00	1,25	6,25	1,13	300
Cow (retired)	7	F	12+	700	0	2300	208	209	0	0	16100	2919	0	0,00	1,25	8,75	1,13	230

Type	Number	Sex (M/F)	Age (years)	Weight (kg)	FM intake/ day (kg)	FM intake/ all
Calf	2	M	0-1	100	7,5	15
Ox (young)	2	M	1-3	600	93	186
Ox (active)	10	M	3-12	900	139,5	1395
Ox (retired)	10	M	12+	900	139,5	1395
Bull	1	M	3-12	1000	155	155
Calf	2	F	0-1	100	7,5	15
Cow (Heifer)	2	F	1-3	475	73,625	147,25
Cow (milking)	4	F	3-12	700	108,5	434
Cow (non- milking)	5	F	3-12	700	108,5	542,5
Cow (retired)	7	F	12+	700	108,5	759,5

APPENDIX III.
INTERVIEWEES

Name: Parta Das (Vilmos Posze)
Function: Head of flower production and ecological resource management
Date of interview: 06.10.2013

Name: Ghanasjama Das
Function: Head of milk production
Date of interview: 05.10.2013

Name: Balamodaka Das (Balazs Antal)
Function: Head of vegetable production
Date of interview: 07.10.2013

Name: Antardi Das
Function: Leader of oxen works
Date of interview: 13.10.2013

Name: Radha-kanta Das (Attila Barsi)
Function: Director of Krishna- valley, director of agriculture
Date of interview: 08.10.2013

Name: Andras Kun
Function: Manager of Ecovalley foundation
Date of interview: 15.10.2013