Fostering organic farming in inter- and transdisciplinary research and teaching –

Case study for Organic Farm System Modelling Bahir Dar, Amhara Region, Ethiopia

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ABBREVIATIONS

ABM .... Agent-based modelling
BDU .... Bahir Dar University
HH .... Household
IFOAM .... International Foundation of Organic Agriculture Movements
LP .... linear programming
MP .... mathematical programming
PM .... Participatory Modelling
PMP .... positive mathematical programming
SD .... system dynamics, system dynamics
WS .... Workshop

ABSTRACT

The demand for higher agricultural outputs to cope with increasing population and degrading natural resources—especially in the African context—calls for alternatives in agricultural practices. Organic farming is one alternative that is tackling such challenges in a holistic and long-term fashion. In the past few decades, farm system modelling has become a new science attempting to simulate agricultural outcomes of potential farm implications. Various models have tried to capture the on-farm processes. Farm system models support the implementation of and learning about newly introduced agricultural practices such as organic and the connected consequences for the farm. Following the organic principles of the *International Federation of Organic Agriculture Movements (IFOAM)* integrates different disciplines and fields following inter- and transdisciplinary guidelines.

In this study, a farm system model has been developed through a participatory modelling process to foster the inter- and transdisciplinary knowledge exchange concerning organic farming. Two groups from the Bahir Dar University and six experts from the private sector and universities were the predominant actors in the modelling process. Four workshops with the Organic Advisory Group, one workshop with the Gender Group as well as several interactive non-structured interviews and meetings with experts of mixed social and natural research backgrounds were conducted. The aim was to exchange knowledge for the creation of a better farm system model according to the local conditions – in the Amhara Region, Ethiopia – and organic farming principles.

The participatory modelling process used here included local knowledge and learning of the participants and researcher. Meanwhile a farm system model was created that includes the main elements and subsystems of an organic farm and their connections with the possibility to calculate potential investments, income, nutrient balances, crop water requirements and productivity. Inter- and transdisciplinary exchange plays a key role concerning this modelling and learning process. Additionally, participant understanding of organic farming and its principles has been broadened and finally the importance of inter- and transdisciplinary research appreciated.

KURZZUSAMMENFASSUNG

Um mit der wachsenden Bevölkerung und der Vernachlässigung der natürlichen Ressourcen speziell im Afrikanischen Kontext umzugehen, bedarf es eine Steigerung der landwirtschaftlichen Erträge. Dies erfordert Alternativen zu den derzeitigen angewandten landwirtschaftlichen Praktiken. Ökologischer Landbau ist eine dieser Alternativen, um die kommenden Herausforderungen auf ganzheitliche und langfristige Weise zu bewältigen. In den vergangenen Jahrzehnten entwickelte sich aus der Forschung zu Betriebsmodellen eine neue Wissenschaft. Diese setzt sich damit auseinander die Auswirkungen von potentiellen Veränderungen auf landwirtschaftliche Erträge zu simulieren. Diverse Modelle haben versucht die Betriebsprozesse nachzuvollziehen und zu integrieren. Betriebsmodelle unterstützen die Implementierung und das Lernen über neu eingeführte landwirtschaftliche Praktiken wie zum Beipiel ökologische Methoden und die damit verbundenen Konsequenzen für den Betrieb. Die ökologischen Prinzipien der *Internationalen Vereinigung der ökologischen Landbaubewegung (IFOAM)* integrieren unterschiedliche Disziplinen und Felder nach inter- und transdisziplinären Richtlinien.

In dieser Arbeit wurde in einem partizipativen Prozess ein Betriebsmodell entwickelt, das den inter- und transdisziplinären Wissensaustausch hinsichtlich ökologischen Landbaus fördert. Zwei Gruppen der Bahir Dar University und sechs Experten aus Privatsektor und Universität haben maßgeblich an dem Modellierungsprozess teilgenommen. Mit der „Organic Advisory Group" wurden insgesamt vier Workshops durchgeführt, ein Workshop mit der Gender Gruppe und diverse interaktive nicht-strukturierte Interviews und Treffen mit den Experten mit natur- oder sozialwissenschaftlichem Hintergrund. Das Ziel war der Wissensaustausch für ein besseres Betriebsmodell angepasst an die lokalen Bedingungen – in der Amhara Region, Äthiopien – und die Prinzipien des Ökolandbaus.

Der partizipative Modellierungsprozess beinhaltet das lokale Wissen und das Lernen der Teilnehmer und Forscher. Es wurde ein Betriebsmodell kreiert, das die Hauptelemente eines ökologischen Betriebs und deren Beziehungen untereinander einbindet mit der Möglichkeit potentielle Investments, Einkommen, Erträge, Nährstoffbilanzen, Pflanzen-Wasser-Bilanz und Produktivität zu berechnen. Inter- und transdisziplinärer Austausch spielt eine Schlüsselrolle im Hinblick auf das Modellieren und Lernen. Das Verständnis der Teilnehmer hinsichtlich ökologischen Landbaus und dessen Prinzipien wurde erweitert und die Wichtigkeit einer inter- und transdisziplinären Forschung gewürdigt.

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1 INTRODUCTION

1.1 Background

Organic farming and the discussion about its potentials is one of the most divers discussed agricultural practices where science and ethics are confronted with each other and opinions, practices as well as research separate in their conclusions. The potential of organic farming practices is well researched and its impacts are certainly stated. The potential for climate challenging environments had been shown in several studies (David Pimentel, 2005). The organic movement is facing an increasing attraction by the western agricultural community while in the same areas agricultural intensification continuously is reaching new peaks concerning practices like fertilizer usage, ploughing and monocultures. The International Foundation of Organic Agriculture Movements (IFOAM) forms an important stakeholder in the discussion about the ethical framework organic farming is acting in (IFAOM, 2016). The four IFOAM principles of Fairness, Ecology, Health and Care trigger a systemic approach in the realization of organic farming regarding the environmental and societal impacts of agricultural production.

Another major impact is driven by the Millennium Development Goals (MDG) and nowadays the Sustainable Development Goals (SDG). The MDGs drove the development and acting into a holistic realization of the future development concerning developing countries as well as industrial countries concerning climate change. The SDGs in continuation of the MDGs include the responsibility of developed countries. Two goals are integrating a sustainable agriculture and use of the ecosystem. The second SDG demands: "*End hunger, achieve food security and improved nutrition and promote sustainable agriculture*". Number fifteen of the SDGs states: "*Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss*" (United Nations, 2016).

The changes in climate include mainly rising temperatures, changing precipitation patterns and an increase of extreme weather events. These effects are influencing the vulnerability and productivity of agricultural practices and farming viability (FAO, 2007). In the tropics and sub-Saharan Africa the expected agricultural impacts will occur till 2030 where agriculture provides the primary source of livelihood for more than 60% of the population (IPCC, 2007). Till 2050 an effect on all agro-ecosystems is assumed (IPCC, 2014).

Until the early 1950's Ethiopia was a self-sufficient country that was in general able to produce enough staple food for its population. With population growth of 15 million in 1951 up to currently 94 Million, the country failed to produce enough food to meet its own requirements already in the early 60's (Sorensen, 2001). The food insecurity is mostly affected by droughts, climate and rainfall variability and structural instabilities of Ethiopia's institutions (Devereux, 2000). Main drivers are among others is the population growth with close linkages to the reduction of landholdings putting increased stress on the natural resource base, the affected soil fertility by intensive cultivation and limited application of yield enhancing inputs (Devereux, 2000). In 2000 87.4% of rural households operated farms with less than 2 ha of land and 80% of the population is depending on their own agriculture – through sales or subsistence. 40.6% operated even less than 0.5ha of land (Gebreselassie, 2006). It is not only about the reduced landholdings but about the degraded state of the land is blamed as a reason for chronic food insecurity in the country (Lal, 2009).

Another institutional challenge are local land property rights. In Ethiopia land is not owned by particular parties like farmers but by the government which lends out the land for certain purposes. Concerning agricultural practices this is putting farmers into an insecure situation. In the last decades there had been a change in land management and cultivation patterns through several projects to strengthen the local agricultural groups. (Deustche Gesellschaft für Internationale Zusammenarbeit , 2016). But meanwhile more and more international organizations invest in Ethiopia's resources. Land is bought by foreign companies to cultivate sustainable roses for the world market and Chinese contractors are building and planning Addis Abeba's infrastructure (ZDF, 2015). These are two negative examples of the external influences of Ethiopia's development. The research proposed is aiming to contribute to the autonomous and independent development options for 80% of Ethiopia's population through the improvement of the situation of smallholder farmers concerning their practices and closely linked returns. This includes social aspects – like traditional practices, participation and societal embeddedness – as well as natural scientific aspects, such as cultivation methods, irrigation schemes and nutrition cycles.

To find measures that cover and fight all the symptoms above and even more tackle the source of the problem has gone on for almost three decades. During this time organic farming practices gained attention and also research efforts have been made. As stated above the potential for organic farming as a solution to these problems is embedded in the holistic and self-sustaining approaches.

Ethiopia already established organic farming practices but till today most organic produces are meant for the export. Concerning the natural challenges Ethiopia is facing – irregular rainfall patterns, higher likelihood of extreme events like droughts – organic farming practices entail the potential to be an alternative to conventional practices. "The aim of organic agriculture is to augment ecological processes that foster plant nutrition yet conserve soil and water resources. Organic systems eliminate agrochemicals and reduce other external inputs to improve the environment and farm economics." (David Pimentel, 2005). Pimentel also shows in the evaluation of a 22-year study with the Rodale Institute that with organic agriculture soil organic matter and nitrogen are higher providing many benefits to the system sustainability and resilience. Especially the soil and water resource conservation create a non-negotiable advantage for the arid and semi-arid regions, like Ethiopia is one. Even though the labor input is about 15% higher than in conventional farming. Through the higher market prices the same economic return can be ensured. Common organic farming practices entail soil and water management that reduces soil erosion, pest problems and pesticide use through crop rotation and cover cropping. The increased biomass in and on the soil is enhancing the biodiversity and through this the pest control and pollinators are attracted (David Pimentel, 2005).

In this study organic farming is seen as an overall baseline. The study is integrating organic farming in the different section and it will come up as the context the study is conducted in. In the different section organic farming will be dealt with and mentioned as an underlying principle that guides the agricultural discussion. This study does not include a section about organic farming as such and it is not explaining particular principles. Nevertheless, the topic will be explained with its components and their interactions in several chapter guiding to the participatory modelling (PM) process.

1.2 Problem Statement

The research deals with an interconnectivity of problems that are found in a lot of developing countries. The University of Bahir Dar as a main partner and interested stakeholder is a key party in this interconnected problem being driving forces for the research. The experts and farmers involved in this research form other parties in this system.

Agricultural research has never been as sophisticated before. There are more people to be fed from the same amount of resources and area. Only in Africa till 2030 440 million jobs need to be created and the agricultural productivity has to enlarged by 60% – through an increase of efficiency or new arable land (Deustche Gesellschaft für Internationale Zusammenarbeit, 2016). Therefore, a lot of research is invested in the increase of efficiency and productivity of agriculture. In the field of technology, the highest investments are done. Since these high investments are mainly linked to contracts and other dependencies that are contradicting with the thought of independence and sovereignty the research for alternatives is limited. The research in organic farming, its efficiency, its potentials and its knowledge transfer is minor compared to the overall research done in agricultural context (Pimentel, Hepperly, Hanson, Douds, & Seidel, 2005).

It has been observed and in the literature about development in countries it is no news that there is a major gap between research that is done, knowledge that is gained and the transfer all way down the path to the researched farmer again. This is a major problem of actual development cooperation known since decades. Therefore, participatory methods have been invented and farmers are supposed to gain back results and innovations. This is working in theory but the most research in development countries in the agricultural sector are still very weak in the dissemination (Groot & Maarleveld, 2000). The researched farmers and farms realize this and lose trust in the advisory services, research institutes and scientists (Cooke, 2001). This engages the negative feedback loop of farmers giving less information and pathways to cope with the upcoming challenges and researchers having a harder time collecting necessary data to identify those.

Through this gap of information transfer potential technologies and pathways don't find their way to the ones that could use it – the farmers. The tendency is to trust economic solutions like the cultivation of advised cash crops that are promoted and for which a market access is assured. The cultivation of one major crop is the most chosen solution. These crops are most often promoted by several stakeholders with a certain economic interest. According to the governmental orientation of the agricultural department the focus of agricultural practices is the export and an economic return as high as possible. Therefore, farming practices have changed in the last decades from traditional practices including the cultivation of several crops for subsistence purposes to technology based farming – pesticides, herbicides and artificial fertilizers (Levasseur & Olivier, 2000; Pimentel et al., 2005). This works in first instance till monocultures exploit the soil fertility and reduce the biodiversity so that yields decrease and crops are performing below the expected minimum yields. This is not only an agricultural issue but includes also a lot of other layers, like the political situation, micro and macro politics of certain agricultural communities, economic independence and dependence of farmers, social structures and many more (Høgh-Jensen, 1998; Wilson, Mann, & Otsuki, 2005).

Through this development in the agricultural sector farmers and especially smallholder have made several steps in the direction of agricultural dependency concerning the seed material, fertilizer and pesticide supply. This led to a contradicting movement away from food sovereignty and security. Ethiopia's population is growing since decades and this trend continues. Approximately 80% of Ethiopia's' population are smallholder with two ha or less. These two ha are decreasing in productivity concerning all characteristics – soil fertility, water holding capacity, organic matter, biodiversity, overall crop productivity and many more. Through this development parts of these two ha are not able to produce any more. Since parts of the farm land are not able to produce any more. The yields are constraint to certain areas of the farm (Holden & Shiferaw, 2004). Attached to this development is the decreased income of smallholder unable to produce for their subsistence.

The problematic situation about this is linked to the loss of alternatives. Through the shift of generations traditional practices are lost and the pool of known agricultural alternatives is continuously decreasing. The main focus of research and teaching is on conventional agricultural practices as it is predominating the agricultural landscape. In the study area and in broader teaching and research context there is no institution dealing with organic farming as such in Amhara Region, Ethiopia. There is a crucial demand for an institution that offers alternative agricultural practices. The education about those practices gives the opportunity to farmers to decide on their own which agricultural practice suits best. The demand of such an institution equally tackles the problem of a missing institute of organic farming. Taking a closer look into the research and teaching sector – especially the agricultural sector at Bahir Dar University – it is notable that certain disciplines are sealed off regarding their field of expertise. Through this the exchange of knowledge and the understanding of farming practices in a wider context obstructs. Certain linkages between subjects – e.g. soil and water – cannot be studied or taught apart from each other since the interactions in an agricultural context are crucial (Brandt et al., 2013; Podestá, Natenzon, Hidalgo, & Ruiz Toranzo, 2013). Not only the exchange between disciplines is of importance for a holistic understanding of agricultural processes but also the transdisciplinary understanding. The exchange with different fields and the understanding of different perspectives and priorities helps to create more resilient approaches (Fiala & Freyer, 2016). As a research and teaching institution it is important to take all involved stakeholder into account to widen the understanding of the agricultural situation.

The teaching and research sector concerning the organic farming is missing proper methods and tools for the transfer of knowledge and expertise. A key problem is the justification concerning organic farming practices and its workability and profitability. This is a vicious circle with on the one hand the argumentation that there is no proof for the workability of organic farming practices in the Amhara Region. On the other hand, there has not been any institutional investment in the teaching and research area since the workability is not proven. Additionally, there is no tool how the concept of organic farming and its practices can be taught on a theoretical level. That way the attention towards alternative and less common agricultural practices is kept low.

This controversial discussed situation is embedded in a culture with farming practices that are integrated in social complexity. The smallholders mostly act in small groups and support each other. One consequence out of this is that the neighboring farmers tend to practice the same cultivation and face also the same problems. To act differently in a social setting like this equals the exclusion from social interaction within the group (Groot & Maarleveld, 2000). Additionally, the role of the women in the HH and agricultural system needs attention. There are key factors of inequality regarding the gender question. Women still do most of the HH-jobs and are working on the fields to support the men. Concerning Wiliams et al (2014) women are associated with social and HH aspects and take over two types of roles – the reproductive and domestic. On the other site men are linked with more rational and productive roles (Wiliams, 2014). This picture found in reality feeds the perception of a male gender that is dominant in every part of societal activity. To encounter this image a woman in Kome's (1997) research stated:

Women work hard in the field. They contribute more labor to the cultivation than men. However, we never try to challenge the men. We think they should retain their position as head of household. Traditionally, a man is seen as the decision maker in the household. This is not the case in reality, but still we allow them go to the Farmers' Organization meetings in that capacity. (Kome, 1997, p. 14)

An example of Nepalese farmers – male and female – show consensus about "women's lack of negotiation skills" (Meinzen-Dick, 1998). Opinions like

When women were not employed, they were considered to be like children because they were controlled and dependent by men. (Wiliams, 2014, p. 54)

show the necessity of one of the most challenging arguments in the gender discussion – education and training (Robert Chambers, 1994b). Concerning Wiliams et al. these gender equity challenges are based on systemic barriers like resource ownership, inheritance and entitlements. The last objective clearly disempowers women in any decision making process and participation (Wiliams, 2014). The *Commission on Social Determinants of Health* states that the “traditional structures can lead to violence against women, fewer options for employment, lesser income for equivalent work, and decreased decision making power” (2008, p.6). To encounter these challenges Cornwall appeals to integrate the knowledge of the locals since they know best why the position of women is neglected in a particular case and situation (Cornwall, 2003). A solution that can be found in many cases is the nominal inclusion of women in participatory projects to fulfil gender goals of a certain agenda (Cornwall, 2006). The creation of access is not enough concerning the inclusion of women. Cornwall results in an analysis that goes “beyond the everyday materialities of people’s lives and move beyond the comfort of consensus”. Franklin argues that the argumentation about real issues need a “safe space” for the discussion of sensitive topics, the argumentation about differing opinions where they are heard and respected. In those spaces the strategies for solving those issues in people’s own lives can be created or at least the first base could be created (Franklin, 2008).

2 CONCEPTUAL FRAMEWORK

This section lays out three key points essential in this research: The research problems addressed; the overall research objectives; the subsequent research questions and the outline of the thesis. The first part deals with the main problems this research is aiming at. Followed by the statement of the research objective where the overall objective and the sub-objective are explained. The research questions section is divided into sub-questions in order to thoroughly answer the main questions and address the overall objectives. Finally, at the end of this chapter the thesis is outlined to ensure for clarity and understanding. The outline illustrates the way the thesis is organized.

2.1 Problems

The specific problems tackled by this study concentrate on local level – Bahir Dar, Ethiopia – and specific chances for the educational system that are seen in the agricultural context concerning organic farming. The extent of the studies' impact needs to be considered in order to reach feasible goals and to align it with its potential outcomes.

The problems tackled by this study are originated on three different levels. The first one includes the challenge of *communication* concerning the exchange of knowledge in and between research, teaching and extension work. The second level is more of a *technology-based* problem. This includes the lack of an integrated model for organic farming to simulate farm processes and to engage in inter- and transdisciplinary research and teaching. The third level of problems deals with the *motivation* in projects in inter- and transdisciplinary settings. This problem can be seen from two sides. Motivation of people from different disciplines and fields to participate in inter- and transdisciplinary projects is a crucial factor for the sustaining of projects. The first perspective takes over the view of the organization. Here participants are hard to motivate beyond projects with direct incentives. The second perspective takes the view of the participants. According to them there are many hurdles for interested possible participants to join those projects. In the following these three problems and the relevance for this study will be discussed in detail.

2.1.1 Communication

The problem of there being a *missing exchange of knowledge and best practice in the agricultural context in research and extension work* originates in the observation of closed disciplinary boundaries. This pattern can be found throughout the entire chain of agricultural business and research. On a university level this implies the creation of wisdom towers where a lot of expertise is gathered and accumulated through research. Since the research influences the teaching at the university level the teaching is therefor caught in its specific disciplinary boundaries. The problem is based in the structural way of how research is understood and supported. In the last decade the trend of inter- and transdisciplinary research has been increasingly supported, especially in the case of development focused research (Brandt et al., 2013; Kerselaers, De Cock, Lauwers, & Van Huylenbroeck, 2007). These researches may consider different stakeholders, participants and their disciplines but often the exchange between those disciplines is minimal. There is useful expertise within the different disciplines but real exchange is not engaged. Even though there are best practice examples of transdisciplinary work, the linkage to research is difficult (Helgenberger & Scholz, 2006; Scholz, Lang, Wiek, Walter, & Stauffacher, 2006). Both gaps, in expertise in disciplines and best practice knowledge, create a base for a solution but have to be integrated in a way of research that let researchers and other parties not only contribute but truly participate. The challenge with the problem of a missing exchange is to engage in a better understanding of how institutions work together and come to a common understanding concerning the expectations and recognition of all participants.

Since organic farming is understood as a system with different elements which is designed and characterized through its relations, research needs to integrate inter- and transdisciplinary approaches (Brandt et al., 2013; Fiala & Freyer, 2016). A large part of the problem occurs because of the exclusion of certain disciplines in different researches. Transdisciplinary projects are usually lengthy and time consuming and taking more time, energy and thus funding to complete (Pohl, Hadorn, & Zimmermann, 2007). The problem includes the perception of agriculture especially organic farming as an inter- and transdisciplinary challenging system and its needs for exchange of expertise and experience.

2.1.2 Technology

The problem described in the following continues with the question of how to enable a communication that has been mentioned in the chapter *Communication.* For inter- and transdisciplinary based research and teaching it would require a method addressing how to combine and teach the most key expertise in organic farming. This method can be and in this study is a modelling tool that integrates all different fields of organic farming and models a farm. Through this modelling process the different linkages between the fields can be comprehended—e.g. crop-water-correlation on farm. There are several existing modelling tools that focus on the certain disciplines[1] but no model, which integrates all factors influencing all farming and household issues. In the chapter *Results* theses will be defined through the system boundaries – adapted to the case of Amhara region, Ethiopia. Crucial to a model is the adaption to differing circumstances concerning cultural, socio-economics, history and furthermore. This entails the amount of adaption that the models is asked to compensate. The problem of the lack of such a model implies another challenge. The degree of detail for such a model is of crucial importance. The detail of such a model could be infinite but it is about choosing a level that is reasonable, to make the participants understand and learn but not to overwhelm them. The problem of *the lack of an integrated model (design) to engage inter- and transdisciplinary based research and teaching* is a technology- and expertise-based problem that requires constant evaluation. Its development is bound to the constraints and problems it is meant to solve(Darnhofer, Gibbon, & Dedieu, 2012; Shrestha, Barnes, & Ahmadi, 2016).

2.1.3 Motivation

The third problem deals with the motivation of involved stakeholders and participants in the long run and what is needed to trigger this in case of all sorts of stakeholders. Several projects have been carried out to facilitate between different interest groups, which motivate stakeholders and participants to join if there is a direct benefit from it (Mitchell, 1973). For decades, scientific research and development projects have aimed to “improve” the livelihood and conditions of so-called poor farmers. Often, their attempts have intervened in existing systems without intrinsically understanding them, often disrupting them or resulting in unhelpful results (Tharenou, 2001). However, there is no one correct way of how to intervene or trigger the motivation for long-term participation and solutions. This study uses participatory modelling as a vehicle to find potential pathways towards long-term solutions within existing agricultural practices. The problem evolving out of this approach is the confrontation of participants with technology that tends to overwhelm them and risks discouraging them. This problem is specifically of interest here and ways to identify overcoming such discouraging momentums and to better embed the used tools and methods in the participants own understanding and motivation are discussed.

As mentioned above, there are two perspectives concerning the c*hallenge of the integration of disciplines and inter- and transdisciplinary oriented participants in the research*. The first one takes on the view of the potential participant who aims to be part of research and teaching projects. With this perspective the hurdles of participation are perceived as too high. The reasons for the hurdles can have several origins—e.g., structural, financial, or institutional. The opposite perspective argues with the incentive driven motivation of participants. Regarding that the project – e.g. research – participation only occurs if there is some incentive. In a transfer of responsibility to local organizations or stakeholders the project would end. The problem often is the understanding of the different motivations concerning a cooperation. The project initiators tend to neglect the participants’

[1] E.g. nutrient cycles; economic models; crop rotation cycles, water requirements; etc.

perspective and situation (Kuehne, 2016). Additionally, the outputs of a project first tend to serve the project owners' interests participants resources and interests are neglected. This results in project outputs often not being able be applied or used by the participants. An integration of participants includes the realization and awareness about their background, motivation and concerns to better understand the perspective and to react appropriately to it and anticipate potential challenges (Crawford & Pollack, 2004).

2.2 Research Objective

In the following section the main research objective and its sub-objectives are given and described. These objectives indicate the intended outcomes of this research.

The main research objective is:

To foster organic farming in order to engage inter- and transdisciplinary research and teaching in the Amhara Region, Ethiopia.

The sub-objectives address the three interlinked problems described above in aiming to:

1. Enable knowledge exchange between actors of different research disciplines and other practical experts from the field.
2. Identify different disciplines and subsystems in farming and households, their relations, specifications and their critical impacts that highly influence a model.
3. Identify the key factors influencing the participants' motivation concerning a participatory modelling process.
4. Enable the long-term integration of inter- & transdisciplinary oriented participants in a participatory modelling process.

These sub-objectives gather and organize information and analyze key issues regarding the stated problems. Once achieved, they will help to tackle these problems—in other words, in true transdisciplinary fashion, the local participants will have the knowledge and ability to develop solutions on their own. The integrated goal is to deliver the local participants a method of how to find pathways to cope with inter- and transdisciplinary challenges in their fields. Therefore, the elements, the system, its interrelations and challenges need to be understood. After having understood this including all potentially important perspectives—the challenge is to integrate them into a learning system. In this study the medium to integrate local knowledge and trigger learning for all involved parties is a participatory modelling process. To develop such a model will help to include different perspectives and expertise of several disciplines.

Since the study is based on participatory methods and engages the inclusion of some participants – see chapter *Organic Advisory Group (OAG)*– through the whole project cycle the achievement of the objectives is bound to the field work.

The main objective follows the standard of the *SMART* principle to support the justification and scientific recognition (Doran, 1981; Lawlor & Hornyak, 2012). It is **S**pecific, **M**easurable, **A**ttainable, **R**ealistic, **T**ime-bound. The research objective is specific because there is a clear definition of the region, the participants and the concept of the model and which data the model contains. It is measurable in a qualitative way since the model will be evaluated by the participants and its specific relevance for a real implementation. Since the Bahir Dar University (BDU) is willing to contribute to increase the university's expertise, the necessary staff is ensured. Additionally, the expertise for the development of a model is given through the cooperating experts and the researcher himself. Additionally, the research objective is attainable and realistic. Concerning the time frame there are two major restrictions: the cooperation with the BDU; and the willingness of the participants. These challenges concerning the feasibility and the complexity of the modelling process are included in the expectations of the fieldwork. Through a clear communication and the setting of realistic goals for the time of the field work these challenges are compensated.

Other literature defines the criteria for appropriate project completion differently—i.e., relevant, feasible, logical, observable, unequivocal, measureable (REF—where are these criteria taken from?). These are majorly comparable to the ones mentioned.

2.3 Research Questions & Hypothesis

The objectives of the research suggest that there are certain questions that need answering in order to give appropriate results and overall outcomes of the research. To address this, the following research question leads us to the answers that are needed:

How can organic farming be fostered to engage inter- and transdisciplinary research and teaching in the case of Amhara Region, Ethiopia?

This general research question needs more detailed analysis. The following sub-research questions help organize eventual answers to the overall question[2]:

1. How can the exchange of knowledge and best practice between actors from different institutions (university, extension services, gender) be enabled?
2. What are the different disciplines to be integrated in a modelling process to ensure an inter- and transdisciplinary approach?
3. What are the key subsystems and how do these interact within the model?
4. Under which circumstances are the outputs of participatory modelling process with inter- and transdisciplinary oriented participants accepted and used by its participants?

In the first sub-question deals with the problem of the communication of inter- and transdisciplinary interaction. The aim is to identify a pathway that can engage an easier communication between the identified disciplines and stakeholder. The first underlying hypotheses is that *inter- and transdisciplinary research and teaching enables the access and the exchange of knowledge. Through an inter- and transdisciplinary discourse current agricultural farming and household challenges can better be understood and analyzed towards potential pathways.* This second hypothesis regarding the question of possible ways to bring an inter- and transdisciplinary discourse into research and teaching states the strong correlation between the integration of different stakeholders and the exchange of knowledge.

The second sub-question sets the system boundaries of organic farming with the goal to integrate as many as necessary disciplines and stakeholders but additionally to find the optimal/critical size of involvement to ensure an effectiveness. Therefore, it is important to ask for the key subsystems and their interaction like in sub-question number three. Here the systems elements and interlinkages are defined and integrated in the study to improve the understanding of the same system. This understanding is crucial for the modelling process so that the model can be setup including all important functionalities of an organic farm out of several inter- and transdisciplinary perspectives. These two research questions aim to get a picture of a farm and its key process that take influence on different subsystem and its development. The hypothesis which is based on those questions is that *a model for organic farming can be setup with gathering all sorts of organic-agricultural important disciplines/experts to either teach or consult concerning farm developments.*

The last sub-question is aiming at the long-term perspective of such a model as a tool to enable the exchange of knowledge. Here the reasons and motivation of participants is analyzed to understand

[2] Throughout the various steps of this study the research questions have been revisited and were specified after the finding of participatory modelling as a potential pathway to answer the main research questions.

and engage in a long-term involvement of the participants that throughout the process learn and achieve (for the project) important capabilities. There are two hypotheses that are going to be tested through the last sub-question. First, *the motivation of participants is long-term if they are included in the complete cycle of modelling.* The second is taking the actual process more into account. *Regular reflection and evaluation of the participatory modelling process and its outputs with the inter- and transdisciplinary oriented participants identifies potential improvements immediate.* This last hypothesis refers to the manner how participatory modelling is implemented and facilitated – more about the how in chapter *Methods.*

3 STATE OF THE ART

Agricultural scientists and practitioners have considered farming models as an essential and useful tool to simulate, analyze and understand farming components relations and farmer decisions about potential changes. The approach aims to simplify the complex models and reduce the amount of input data. The chapter describes the actual situation in the field of (organic) farming models and describes the actual state of the art including the challenges and the outlook.

Over the last decades models have been setup and created a specific family of simulation models e.g. integrated, socio-ecological or bio-economic models (Feola, Sattler, & Saysel, 2012). These models are able to simulate more than a single specific environmental compartment or one process of the farming system. The additional data of the model process that gives an indication about the system components and subsystems that are in focus. Additionally, these farming systems models entail social components – e.g. economy, institution – to holistically represent the different processes. Two main interaction are influencing here. The progress in the conceptualization of farming systems allows to include all important scientific and natural sub-systems and interlinkages within the farming system (Bawden, 1995). The second point is the inclusion of the farmers' understanding as a key actor in the system (Darnhofer et al., 2012; Feola & Binder, 2010). Therefore, simulation models are important for the research to better understand the complexities and dynamics in a certain farming system (Feola & Binder, 2010; Janssen & Van Ittersum, 2007; Milestad, Dedieu, Darnhofer, & Bellon, 2012).

As Feola et al. (2012) state the models often have different and overlapping goals that vary from farm optimization, stainability assessment to policy evaluation. To involve stakeholder and actors the models are increasingly used for inter- and transdisciplinary processes to integrate those perspectives (Feola et al., 2012).

The methods and techniques that are used for the modelling depend on the purpose, functionality and the disciplinary boundaries of the conducted research. In the following, there are three different techniques described – linear programming (LP) in a wider setup of positive mathematical programming (PMP), system dynamics (SD), and agent-based modelling (ABM. Often the theoretical base for the modelling is a challenge including the institutions, social agents, model calibration and validation, the involvement of stakeholders and users in the modelling process and dissemination process (Feola et al., 2012). This gives already an insight to the complexity modelling in farming systems research. How this study is dealing with this topic is explained in the chapter *Systems Thinking.*

3.1 Mathematical/Linear Programming in the Agricultural Context

As described by Arfini et al (2016) one way of describing a model is concerning the approaches of the European Union. This method is called positive mathematical programming (PMP) and originates in the linear programming (LP). PMP goes a step further than the common mathematical (linear) programming (MP. It is able to adapt on different levels of aggregation – e.g. regional level, farm types or individual farms.

3.1.1 Linear Programming

LP formed the base for MP in the agricultural sector integrating direct farmers information (Norton & Hazell, 1986). LP models are able to describe "primal and dual information in detail for each farm" (Arfini, Donati, Solazzo, & Veneziani, 2016). Additionally, relations between different farm activities and their relationships with product markets and input factors are included. The practices of LP were meant to support production decisions. LP is used for large scale productions in more monoculture dominated surrounding. This is contradicting with the organic principles. The aim of LP is to achieve an objective. This might be the optimization of a farm output. There are certain constraints specifying over which conditions the objective function is to be optimized. In the agricultural sector the elements are predominantly the objective function (set of maximizing the total gross margin), the farming activities (crops and livestock), the constraints (resources) and technological coefficients (relating to the constraints e.g. labor, land) (Feola et al., 2012). The application for LP is found in the field of studying different farming systems – dairy, crop, beef and forestry (Bartolini, Bazzani, Gallerani, Raggi, & Viaggi, 2007; Bertomeu & Giménez, 2006; Fokkens & Puylaert, 1981; Wilton, Morris, Leigh, Jenson, & Pfeiffer, 1974; Zimmermann, 2008). Additionally it can be found in the ways of transitions from conventional to organic farming (Kerselaers et al., 2007), and trade-off analysis. This is covering the natural components for farming systems research. More widely it also is used for the analysis of policy impacts on farm level and environmental impact assessments (Ramsden, Gibbons, & Wilson, 1999). Even social and sustainability assessment are done with the help of LP (Amede & Delve, 2008; Dogliotti, Van Ittersum, & Rossing, 2005). Concluding, the strength of LP definitely is originated in the easy and fast simulation of very detailed sub-systems and can be applied on single farm level or widen contexts (Feola et al., 2012).

The challenges entail on the one hand the difficulty in defining the statistically representative economic and technical information about farmers' reality. On the other hand, there are limited information in the databases that provide sufficient insight about the production costs of farmers. Another factor is that smallholders are easily neglected in the LP because the assumptions and numbers deviate in unrealistic scales what makes the outcome of the model unreliable (Paris & Howitt, 1998). Additionally, the usual outcome of a LP model is a normative aim and the difference between farmers production reality and the modeled outcome is explained with the inefficiency of farmers (Arfini et al., 2016). Till now LP has found its master in the simplex algorithm that calculates the global optimum (Danzig & Thapa, 1997).

Application examples of LP can be found in the field of simulating single components or wider connected simulations of a farm. Two examples are (1) the ROTOR model from Bachinger and (2) CropSyst of the Washingtion State University. As Bachinger et al. (2007) explain in *ROTOR, a tool for generating and evaluating crop rotations for organic farming systems* the modelling tool ROTOR is calculating potential crop rotations of a farm. Therefore, certain crop production activities and site specification form the data base of the model. The outcome is about to give better indication in the potential planning results. The focus is on the Nitrogen-household of organic crop rotations since this is a sensible topic in organic farming systems (Bachinger & Zander, 2007). Nevertheless, this model ignores the farm level information and certain interactions important in the organic farming principles like fodder-manure cycle. There certain sources of Nitrogen are ignored which are crucial in the closed loop understanding of an organic farm. The most advanced LP tool that could be found in the literature review is *CropSyst* from Dr. Stöckle of the Washington State University. This model is best described as such:

> *CropSyst is a is a user-friendly, conceptually simple but sound multi-year multi-crop daily time step simulation model. The model has been developed to serve as an analytic tool to study the effect of cropping systems management on productivity and the environment. The model simulates the soil water budget, soil-plant nitrogen budget, crop canopy and root growth, dry matter production, yield, residue production and decomposition, and erosion. Management options include: cultivar selection, crop rotation (including fallow years), irrigation, nitrogen fertilization, tillage operations (over 80 options), and residue management. The model is currently written in C++. (Stöckle, Nelson, & Kemanian, 2017)*

This model tackles a lot more topics that the previous one. The wide range of analysis focusing on crop production gives a clear and holistic picture about the in- and outputs for cropping practices (Stockle, Martin, & Campbell, 1994). The crop rotation can be adapted and fallow years might be added to the rotation schedule according to organic principles. The model gives a good overview about the agricultural productivity but excludes the understanding of the farm as an interactive whole with several different interlinked sub-systems.

Additionally, there can be found various modelling tools in the crop production sector like *Agronomy Calculus* or the FAO tools *CropWat, Aquacrop, ClimWat*. All these are made for specific modelling purposes and none of those covers a farm on a holistic level.

3.1.2 Positive Mathematical Programming

Out of the earlier named challenges and constraints the need for a new modelling approach had arisen. PMP is meant to better integrate the factors of farmers' perspectives. There are costs that are linked to the HHs and other constraints that are better seen by farmers instead of external experts. The environmental, social and technical problems in the agricultural context are associated with the on farm, local and regional characteristics have tendencies to a more individual management (Heckelei, 2014). The change that some researcher made in their methodologies supports the entrepreneurial behaviors of farmers and developed from a normative approach to a non-linear method of programming – PMP (Arfini et al., 2016; Paris & Howitt, 1998). Nevertheless, this new method developed and since there is no clear definition but taking into account the non-linear development of farms the variations of this approach are diverse.

Important for this study is to realize the linkages between other external factors like shocks, risks (economically and naturally) and uncertainties. In order to prevent the model failures the programming method needs to imply such uncertainties (Arfini et al., 2016). The PMP delivers an option that allows the combination of a more resilient and empirically based specification combined with the technology-rich formulation of MP models. Another influencing factor are the increasing food concerns which have been realized by experts and researchers and nowadays conclude in an integrated analysis of the food supply chain down till the "origin of most raw material for food production" (Heckelei, 2014, p. 207).

The PMP approaches are often linked to policy makers and decisions that need better estimations about farm level decisions. Therefore, according to Shresta et al. (2016) state that PMP is integrating the necessary decision into account and give orientation in the programming outcomes. The variables taken into account go into a simulation process described as microsimulation (O'Donoghue, 2016). Within this simulation certain areas of a farm are modeled following a reductionist approach.

An outlook to the future of PMP is given through the development of new technologies. Databases are widening with increasing speed. Computing power is accelerating with new generations of processors and its availability in the last decades has increased tremendously so that even poor farmer communities have access to the internet. These trends make simulation in form of PMP even more suitable since the method increases its potential with increasing databases (Heckelei, 2014).

3.2 System Dynamics

This second type of modelling category – system dynamics (SD)– has its roots at the MIT Sloan Management School in the system dynamics group in the 70s (Forrester, 1994). The foundation of system dynamics is the modern system thinking and the influencing dynamics that came from the global sustainability assessment of Dennis Meadows (Meadows, Randers, & Meadows, 2004). The guideline for the system dynamic modelling is through (1) problem dynamic identification, (2) closed loop hypothesis generation, (3) model identification, (4) validation and (5) scenario and policy analysis with computer simulation. The underlying principle in SD is the system. As such SD entails a "holistic and interdisciplinary approach to dynamically complex real-life problems" (Feola et al., 2012, p. 288).

3.2.1 The structure

In the first stage the *closed-loop dynamic problem identification* takes place. Therefore, a certain problem is observed and the interactions of different processes are analyzed. Through this procedure it is ensured that all influences are taken into account and the loop is closed (Feola et al., 2012). In this procedure it is important that a *manager* is embedded in the system itself. In most cases farmers are asked to take over that position since they know the system best (Saysel, Barlas, & Yenigün, 2002).

The second phase is meant to define the *dynamic hypothesis*. That classically requires a dynamic problem which is defined through a causal loop diagram. Its variables are integrated in a feedback scheme where these are influenced by and influence each other. Its influences can be positive (enhancing each other) or negative (weaken each other) (Feola et al., 2012). The causality of the feedbacks is a key to understand the processes and origins of the dynamic problem.

The third step is the actual creation of a computer-based model. These models are normally high-order non-linear systems including differential equations. In these models a reductionist approach is not working to analyze the systems behavior. The single parts of the farm cannot be separated from each other. The outcomes are numeric simulations and the model structure is based on the stocks, flows, delays and non-linearities (Feola et al., 2012). The model structure is based on the different physical and environmental components of a system but additionally integrate the decision processes of actors within this system. Therefore, so called decision rules are programmed that give a certain indication of possible feedback that influences the actual simulation. SD is describing the sources and channels of information and not their optimum. Formal procedures include the validation of the model structure "as an adequate representation of the real system with respect to the particular purpose of the analysis" (Feola et al., 2012). A key element in the process of modelling is that the modeler is forced to reflect on his own mental model of the problem. This process carries already a lot of complexity concerning small models and tends to easily overstrain the modelers capacities (Saysel & Barlas, 2006).

In the last stage the scenarios and policy analysis is taking place. This stage often tends to entail participatory processes since it is essential to overcome the exclusion of certain perspectives (Vennix, 1996). A simple model structure has already the capability to transport a certain systemic understanding and causes of the dynamic problem that can give insight to potential solutions. Special attention is needed for the tension between detail and simplicity. The criteria of sufficiency are depending on the analysis and its purpose and are meant to be figured out in the iterative process of the building of the model.

3.2.2 The application

The application of SD is dominated through a wider understanding of complexities and teaching or learning processes about these complexities. This entails global, national and regional research levels. Attempts of holistic system analysis neglect the individual farm levels but concentrate more on holistic management issues (Feola et al., 2012). Precise application are in a closer farm level context crop growth and management (Yin & Struik, 2010), livestock farming and animal diseases control (Rich, 2008), pastures and sheep farming (Mashayekhi, 1990) and aquaculture farming (Arquitt, Honggangb, & Johnstonea, 2005). On a more management level that integrates national and global levels are rural energy systems (Alam, Bala, & Huq, 1997), development of environmentally friendly farm systems (Shi & Gill, 2005), irrigation design management (Saysel et al., 2002), soil degradation (Saysel & Barlas, 2001), food supply and security (Georgiadis, Vlachos, & Iakovou, 2005), agricultural development policy (Weber & Schwaninger, 2002) and forestry management (Dudley, 2004).

3.3 Agent-based modelling

3.3.1 Characteristics

The agent-based modelling describes a model process in which the key figures are the agents that have been predefined. These are about to act in a certain environment and interact with constraints. The key functionality of the agents is to interact with others and take decisions. These decisions have influence according to programmed relationships, rules and operations – **Error! Reference source not found.** (Bousquet & Le Page, 2004).

In ABM the correlations between different agents in their environment is tried to model concerning certain properties and in a predefined system behavior. This means that in an ABM the examination according to a special interest and certain practices or phenomena is handled. The properties define the framework (under which circumstances?) of the ABM while the emerging system behavior is the topic that is aimed to be studied.

Table 1: Elements of agent-based models, and examples (modified after (Feola et al., 2012))

ABM characteristics	Examples
Agents	Farmer, farm HH
Environment	Agriculture unit, river catchment
Relationships	Observe; exchange information
Rules	Imitate, calculate
Operations	Cultivate/Fallow; rotate crop/same crop; cultivate crop x/crop y
Properties	Risk aversion; educational level; location in the environment
Emerging system behavior	Land use pattern; diffusion of innovative technology

Within this type of model the complex behavior patterns can be examined. This approach makes it impossible to break the system down to its single elements. Therefore, computer models are used to simulate these interlinked processes (Bonabeau, 2002).

A crucial difference to the other modelling processes is the fact that ABMs' structure and rules need to be designed bottom up. This happens through the representing role of the agents who entail the rules of the model from which the system emerges. This opens the opportunity for agents to make unanticipated behavior visible to the system externals (Bonabeau, 2002).

3.3.2 Application

The application of ABM covers a wider social, policy and environmental context ranging from ex-ante assessment of policy impacts to watershed management. The focus of ABMs' application is sourced in the management of natural resources but at the same time integrating the socially influenced decisions. The range of what might be an agent in the particular case is open since it depends on the purpose of the analysis – e.g. it can be a farmer or even a household (HH) (Feola et al., 2012). There might even be different agents in one and the same model still linked to the same level of analysis – farm, community, or region. The model building process in ABM requires a database generation for each agent. Therefore, the application of ABM on single farm level is not suited even though the modelling is easier in smaller systems (Happe, Kellermann, & Balmann, 2006). The parameterization of those models tend to include diverse sources e.g. qualitative interviews, grey literature, focus groups, key informants (Voinov & Bousquet, 2010).

3.3.3 Chances & Challenges

The underlying chances of ABM can be fully explored when there is a heterogeneous population of agents. This means for example that neighboring farmers have the same practices and mindset, that environmental conditions are steady in the modeled areas (Bonabeau, 2002). Concerning ABMs on a regional scale an advantage is the linkage with other simulation tools of the natural science sector like GIS. Through this linkage essential developments can be modelled down to regional impacts (Etienne, Le Page, & Cohen, 2003). A main challenge in the modelling process is to model the agents complex enough to simulate realistic behavioral patterns but not too detailed to avoid confusion and data overloads (Bousquet & Le Page, 2004).

The challenges ABMs are facing are concerning the tremendous costs, empirical data and validation. For a proper modelling data should be generated in quantitative and qualitative ways. This combination of data is in consequence more creative than scientifically accepted. This results in questionable validation problems since there is no possibility to compare the simulation data to reality or other generated outcomes (Bonabeau, 2002; Freeman, Nolan, & Schoney, 2009).

On a wider scope, ABMs are not meant to reconstruct reality and model the systems in a deterministic way rather than giving a constructivist idea about a model/system (Bousquet & Le Page, 2004; Voinov & Bousquet, 2010). ABM denies a clear prediction about economic and environmental outcomes rather than pointing out the complexity of systems and making externals able to understand the underlying patterns and developments (Feola et al., 2012).

4 THEORETICAL FRAMEWORK

In this chapter, the underlying theories that are important for the study will be discussed. Two main theories play an important role this research. These are the base for understanding the context of organic farming and further develop achieve the aims of this study. First *systems thinking* is introduced and the relevant concepts and approaches that have evolved from it. A closer look will be taken concerning the concepts of *soft and hard systems* and *system dynamics*. The second theory – *theory of participation* – leads to the approach of participatory modelling.

4.1 Systems Thinking

Systems thinking has evolved out of the theory of holism in the 1920's of Smuts. Out of the holism thought general system theory developed in the 1940s with the work of Bertalanffy and one decade later with the cybernetics of Ashby (Ashby, 1991; Von Bertalanffy, 1968). Another important player in the development of systems thinking has been situated at the MIT with the Society of Organizational Learning and the leader Jay Forrester (Forrester, 1993). In the 80s and 90s the theory got popular and authors like Peter Senge published their work and spread the approach (Peter M Senge, 2014; Peter M. Senge & Sterman, 1992). Systems Thinking turned into a new approach how the solve problems that needed a holistic perspective and at the same time reductionist thinking.

Within the available scientific literature many authors state system thinking as basis for understanding constructs with advanced complexities (P. Checkland, 1981; Kauffman, 1980; Von Bertalanffy, 1968). In other words, in order to learn more about something that has been done for several decades, dividing the object of study into smaller and smaller pieces can be helpful. The logical conclusion has been that a system is nothing more than the sum of its parts. The extreme of this is called "reductionism". Within every discipline, the discipline develops its own theories about itself, their relation to other disciplines and the disciplines' perception of others. After researchers had made the discovery that no matter which system they analyzed the patterns and the organization was the same, *general system theory* was born. One of the major advantages of systems theory was the possibility of tackling messy and chaotic real-world problems that do not fit into one particular discipline. Another advantage is that these chaotic problems become understandable to people that did not necessarily study a certain discipline (Kauffman, 1980). System thinking offers important concepts and tools to analyze a system and comprehend its elements and internal correlations.

In this research, we focus on organic agriculture as a system. This can be seen as such due to the fact that the different disciplines included in organic agriculture are interrelated and influence each other (Fiala & Freyer, 2016). In organic agriculture, the aim is to create synergies between certain parts and to engage in a closed loop thinking. The different parts that belong to the definition of organic farming influence each other. These influences get special attention in organic farming. To understand the ongoing processes in one part of the farm it is necessary to take the process of other influencing parts into account. A holistic overview of the subsystems in organic farming match with the definition of the description of a system in systems thinking. In the application of system thinking it is important to reflect upon the specific purpose in which system thinking is being used for. There are several variations of how system thinking can be interpreted. In the following, two types of systems thinking are described as they will both be taken into account for this study.

4.1.1 Hard systems thinking

Discussing systems inevitably leads to the necessity of the differentiation of soft and hard systems. The hard systems thinking category describes models of systems which tend to achieve a close link to reality (P. Checkland, 1981; P. B. Checkland, 1978). This developed out of thinking about systems in an applied manner to create problem solving methods that are able to simulate real complexities. The roots for hard system thinking are in the systems' engineering and analysis meant for the simulation of complex processes and their outcomes. Underlying the whole bundle of approaches that are entailed in the category of hard systems thinking is "the assumption that the problem task they tackle is to select an efficient means of achieving a known and defined end." (P. B. Checkland, 1978). Hard approaches include time, cost and quality (Crawford & Pollack, 2004). During the last decades hard systems thinking has been criticized for its drift into number based and mathematical methods. This category is also called the first generation of system thinking. Linked to that generation are several understandings and interpretations that are underlying prerequisites in understanding the way of thinking. For hard systems thinking this concludes in the conception of reality which is countable and independent from the perception. Here, objectivity is the base for observations and experiments through which the world can be explained (verification and falsification). Nevertheless, past projects following hard systems thinking tended to fail because the management of the projects or programs did not pay attention to soft criteria, like management, social integration (see chapter *Soft systems thinking*). Hard methods tend to exclude participation of different stakeholders outside the certain field but are able to be accomplish faster. Through this fast delivering approach the chances for innovation and inclusion of stakeholders are limited (Crawford & Pollack, 2004).

4.1.2 Soft systems thinking

Complementing hard systems thinking is, of course, soft systems thinking. This category evolved out of the ineffectiveness of hard systems thinking approaches to cover both, physical and social systems (Forrester, 1994). In this category, a system cannot be explained through the single entities it is made of. Perception is not excluding the beholders perspective. There is constant interpretation of the influence and the world view is dominated by what the beholder perceives (Bawden, 1995). The social component is influencing the approaches in the soft systems thinking category. Soft criteria include "community, perception, safety, environmental impacts, legal acceptability, political and social impacts… stakeholders, value management, and communications." (Crawford & Pollack, 2004, p. 643). Systems are seen as tools for learning about complex situations. Additionally, the soft systems thinking approaches are meant to create consensus and offer possible solutions for problems between affected persons (Crawford & Pollack, 2004; Fiala & Freyer, 2016). Soft methods originating in the soft systems thinking acknowledge any ambiguity, focusing on learning, exploration and through this it is more about the debate and the exploration of alternatives than on the efficient delivery (Crawford & Pollack, 2004).

4.1.3 Inter- & transdisciplinarity in systems understanding

A systems perspective includes several issues that influence the total system. The beholder decides where to draw the borders of the system. This decision is most likely not linked to certain disciplines but based on the purpose the system is serving (in the view of the beholder). Often this includes a diverse range of disciplines and fields. With this, system thinking automatically integrates inter- and transdisciplinary views in its definition. The division of soft and hard systems thinking can be linked to the categorization between inter- and transdisciplinary approaches.

According to Gibbon (2002) the interdisciplinarity of research in the organic field is essential since it is dealing with "complex, inter-related systems of crops, pests, diseases, nutrients, livestock and human resource management." (Gibbon, 2002, p. 3). To analyze and cooperate beyond disciplinary borders is key in understanding and creating an appropriate impact in a program or project. Most scientists are still trained in increasingly narrow disciplinary fields. Because of this the capability to understand and act within a situation, which asks for a more holistic perspective and thinking, is lacking and tends to be more ineffective. This is also seen in institutional and structural examples since the interdisciplinary interaction between natural and social scientist is often not encouraged (Gibbon, 2002). To cope with such a challenging situation one promising pathway to constructive change can be the willingness of scientists to learn and adapt through their interaction with farmers. Author, philosopher and farmer Wendell Berry discussed the uncommon role farmers have in addressing specialization in society in his pivotal work *The Unsettling of America* (1977). He identified farmers as generalists, professionals of not one specialized branch, but in the act of farming, a collection of disciplines such as animal husbandry, soil ecologist, meteorologist, plant specialist, machinist, accountant, etc. Thus, as farming is inherently transdisciplinary in nature, can be an incredibly beneficial field in which to connect scientists from various disciplines as well as stakeholders from different specializations.

Nevertheless, in most researches interdisciplinarity is a “significant research challenge” (Nicholson et al., 2009, p. 1143) attempting to integrate rather than simply gather different disciplines. Ison (1999) and Tait et al (1997) describe the link between system thinking and interdisciplinarity in the way how interdisciplinarity is “conceptualized and facilitated by organizational and structural arrangements…” (Ison, 1999, p. 109; Tait, Morris, & Ison, 1997). That implies the understanding of interdisciplinary processes based on system thinking. Through system thinking the interdisciplinary understanding of processes and projects is enabled.

System thinking goes beyond the definition of a certain field. It percolates through all affected areas of related projects and programs. Helgenberger (2006) describes the problem solution between science and society as a transdisciplinary research-cooperation which is able to tackle complex problems (Helgenberger & Scholz, 2006). Scholz et al (2006) further defines transdisciplinarity according to three parts:

1. “supplementing traditional, disciplinary- and problem-centred "interdisciplinary” scientific activities by organizing processes to incorporate procedures, methodologies, knowledge, and goals from science, industry, and politics;
2. starting science production from relevant, complex societal problems, thus having the potential to contribute to sustainable development;
3. organizing processes of mutual learning between science and society, so that people from outside academia can participate in transdisciplinary processes.”

These three parts are describing the (1) methodological way of generating scientific knowledge, (2) the kind and origin of the problem and (3) the relation of science and society into account. For this study the definitions of 1. and 2. play an important role. In the center of transdisciplinary approaches are complex problems that are linked to any part of society or have influence/an impact on it. Through transdisciplinary processes the interaction of several fields and parts of society interact leading first, to a better understanding of the problem and its origin and second, increases the effectiveness of processes (Helgenberger & Scholz, 2006).

This idea of transdisciplinarity is closely linked to the theory of soft systems thinking. Both argue for the integration of societal / social perspectives in any process to better understand the problems and increase the effectiveness of certain solution processes. In Figure 1 the interlinkages between the different theories are displayed as argued for this study. The hard systems thinking approach – system dynamics – connects with the understanding of interdisciplinarity. The fitting approach is the system dynamics, which helps to model complex systems. The interdisciplinarity and the system dynamics approach – both originating from hard systems thinking – need to be embedded in a wider context to allow it to make an impact. Therefore, in this research soft systems thinking and transdisciplinarity build a theoretical framework that allows the findings and simulation through system dynamics to be embedded in a social and societal context.

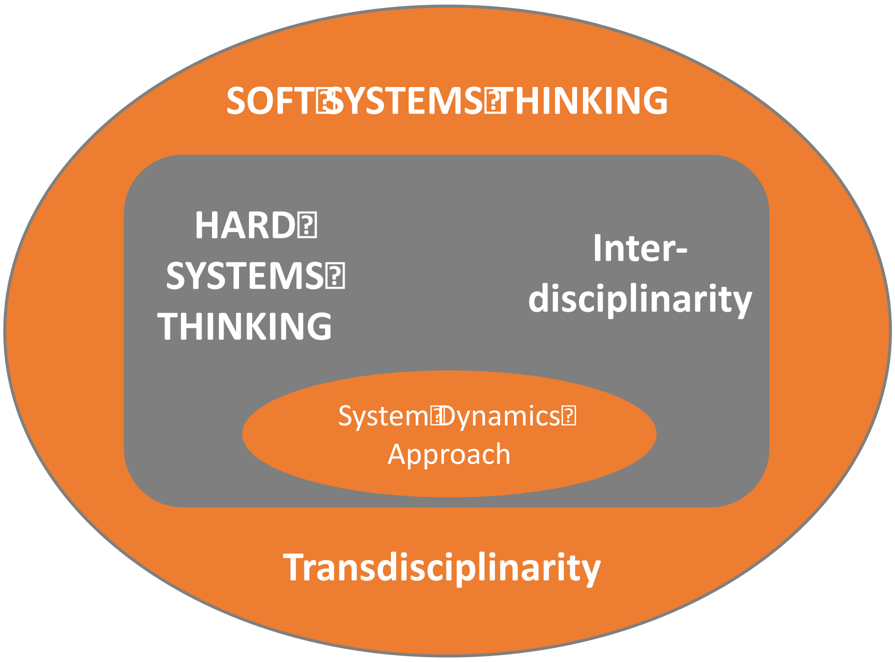


Figure 1: Theoretical Framework

Illustration of the theoretical framework used in this research depicting: the relationships and connections between hard systems thinking and interdisciplinarity with the approach of system dynamics, embedded in soft systems thinking and transdisciplinarity.

4.2 Participation

This chapter first gives an overview about the history of participation and especially of participation in the development work context. Further it points out the different approaches in participation and the tendencies that developed through the decades in direction of Participatory Rural Appraisal and how this got an umbrella for a whole *family* of participatory methods. Concluding the relation of formerly widespread Rapid Rural Appraisal approaches and the younger PRA-approaches shows a more interlinked picture of these approaches. In the following subsections three main topics in the participatory context of this study are explained – facilitation, gender and participatory groups. These give detailed information and insight about the background and the challenges of the decisions made in this study concerning participation.

Often participation in the development context is called participatory development. In both cases, it is meant as a method offering an alternative to the top-down development. Participation in development has a history reaching from the 1940s to the present – all in different forms. In the 1940s to the 1960s the approach was under the colonial aim of community development. Participation was that time restricted to the creation of state hegemony. It has been used as an obligation of citizenship. In the 1960s participation got a new glimpse in the political context – in terms of voting as political participation. The 1970s were dominated by an understanding of participation as in an emancipatory way where participation turned from an obligation of citizenship to a right of citizenship. Emerging from the 70s as a new approach to satisfy the basic needs of 'the poor' participation has been integrated in the understanding of citizenship (Cornwall, 2002). In the 80s participation evolved into the focus on participation in projects rather than in broader political communities. Through this local involvement was aimed to be triggered while the first development professionals and agencies picked up the topic (Hickey & Mohan, 2004). Participation in development context developed popularity in the 90s. It was common-sense that certain issues went wrong in the development sectors and participation seemed to be an option to strike some of them (Cornwall, 2006).Till today the paradigm of participation as a right of citizenship is consistent through the approach of participatory governance and citizenship participation (these approaches are not part of this study). According to Hickey et al (2004) the term participation has often been misused for any purpose of tyranny – e.g. in the concepts of citizenship participation was chosen to control the rural population.

Participation is essential to effect the systemic change in mindset associated with the development transformation,… (Stiglitz, 2002, p. 168)

There a several definitions and degrees of participation in the development. Development as such represents a transformation from one state – often a traditional – to another – often more modern one. The field of development is focusing on the change or transformations in society (Stiglitz, 2002). Participation in its broadest sense is frequently used to "encompass transparency, openness and voice in both public and corporate settings" (Stiglitz, 2002, p. 165). This is happening through a process where these different points evolve and outcomes are not in the focus. There is a recognition of the differences between actions taken and those who are effected by the actions. Participation is a trial to minimize that gap and take the effected one in the setup to better understand the interests and needs of the ones that benefit. Hickey et al (2004) point out the importance of connected agencies or organization that are able to implement and accompany a participatory process to ensure the inclusion of all perspectives. Another characterization that needs special attention concerning participation and the connected aims is the temporality. Participation in projects mainly is time bound but the changes – e.g. in society or in tradition – that are aimed to be triggered might extent and develop over years (Hickey & Mohan, 2004). Therefore, it is important to set a participatory project in a way that participants and affected groups are prepared to be able to manage the processes after the project finalization themselves.

In the 80s the well-known methods of Participatory Rural Appraisal (PRA) entered the development discourse out of the Rapid Rural Appraisal (RRA), activist participatory research, agroecosystem analysis, applied anthropology, field research on farming systems (Robert Chambers, 1994a). The RRA has been focusing on the fast extraction of data in the field. That changed into the recognition of people and their behavior and traditions as key informants for a successful project implementation. Since then it has developed to one of the biggest methodologies so that participation implied PRA (Brown, Howes, Hussein, Longley, & Swindell, 2002).

PRA describes a growing family of approaches and methods to enable local people to share, enhance and analyze their knowledge to life and conditions, to plan and to act. (Robert Chambers, 1994a, p. 953)

This family of approaches and methods will be narrowed down to the relevant points in the chapter *Methods*. These methods and approaches have underlying principles of PRA – as relevant for this study – in common:

- *Handing over the stick:* surrendering authority to local people in learning processes
- *Self-critical awareness*: critical examination and reflection by and of facilitators of their own roles and learning
- *Personal responsibility*: the use of the own best judgement at all times independent from which position in PRA
- *Sharing*: ideas and information have to be spread widely to encourage the transparency.

According to the literature there are several additional principles e.g. the stimulation of 'community awareness' (Robert Chambers, 1994b). The basic consensus of PRA is the engagement and stimulation of a more general process of change and empowerment (Brown et al., 2002; Groot & Maarleveld, 2000; Stave, 2010). The research methods of PRA gained popularity and new forms developed like Participatory Learning and Action (PLA). The RRA which tends to be more extractive has become a well-established tool for a lot of researching institutes and institutions. The PRA in contrast still is strongly associated to the work of NGOs or social research institutions (LODWICK & Cernea, 1991). Today's development work argues with a situational debate of which methods and tools to use. Brown et al (2002) delivers four basic criteria if PRA entails a method fitting the actual study/research or not.

1. *Utilitarian considerations:* This factor defines the effectiveness of the data collection, the overall costs and the context which the project is embedded in. Is it more efficient and effective to collect the data in a PRA-approach with lower costs and in an action research or policy-relevant context than PRA is the choice.
2. *Community mobilisation:* Here the inclusion of communities during data collection plays a major role. Is there intended benefits for the communities or involved groups it is important to use a PRA-approach.
3. *Motivational benefits:* The factor of motivation deals with the motivation of development workers and community members. With PRA there is higher generated empathy and sharing.
4. *Empowering the beneficiaries:* According to the literature PRA creates empowerment of the involved people and communities which is able to lead and foster social change. In this field there are major doubts concerning the long-term sustainability (Groot & Maarleveld, 2000). A project and with it the change tend to end as soon as the project initiators are gone again.

As Chambers (1994) stated already in a comparatively early stage of participatory approaches these methods underlie certain criteria benchmarking former methods. In **Error! Reference source not found.** the example of the development from RRA to PRA. Participation in general and specifically through participatory methods like PRA entail two main prerequisites – a facilitator and a group of local people. Since development work is a cooperation between cultural and societal in- and outsiders the perspectives on that cooperation of the involved parties can have great impact. The displayed continuum in **Error! Reference source not found.** is a simplified mirror to the development reality. In

PRA methods, there are still parts that extract certain information or capacities while integrating it in a broader context and making it useful for the empowerment of local people. Nevertheless, a crucial difference between projects in development work are given by the degree of participation.

Table 2: The RRA-PRA continuum (modified according to (Robert Chambers, 1994a))

Nature of process	**RRA**			**PRA**
Mode	Extractive	Elective	Sharing	Empowering
Outsider's role	Investigator			Facilitator
Information owned, analysed and used by	Outsiders			Local people

The term participation in this study will be used for the way of how local people, knowledge and expertise is integrated in the research. Two important assumptions are made based on this chapter and the study's' objectives. First, for the participatory part of this study a facilitator (*Facilitator*) is needed to guide through the process in whatever way. Second, since the objectives and the framework of this study is including a perspective on or of gender (*Gender*) related issues in the context there is the need of special attention to this topic. This can only be integrated in the participation since this topic needs a wider perspective than the researchers can provide.

4.2.1 Facilitator

In this chapter, the role of the facilitator and the justification for a facilitation process is discussed based on the state of the art concerning this topic. The question what is facilitation and for which purpose can it serve will be answered first. The facilitation in this research aims at the communicational bridging between different parties and additionally the expertise communication and teaching about the participatory model and its content.

4.2.1.1 Why facilitation?

Facilitation has a long history regarding the development context and other fields. It went through different definitions and the process itself developed through the years and experiences of development cooperation. It started in the education sector where didactic teaching developed to experimental and group learning (Dewey, 1916). At the end of the 20st century facilitation got introduced to other disciplines like management, the feminist and peace movements and development work (Hogan, 2005). In the early stage facilitation was the opposite of what is defined nowadays to be facilitation. The main pattern why facilitation is needed is the communicational gap between two or more cultures, two or more interest, etc. The facilitation is the bridge that is built between the different groups. In this regard, it might be asked why a communication is needed at all but this will be discussed in detail in the chapter *Challenges & Chances.*

The focus of this paragraph is on the positive site that implies a communication between stakeholder in a project. The aim is here to find a way of bridging certain gaps between stakeholders with different backgrounds and interests in a project. The facilitation idealistically opens a space for exchange between stakeholders with differences – also in cultural and societal standing. To engage everybody equally in a contribution the facilitation process levels those differences in a supporting manner. To involve all selected participants and stakeholders in the same way is the major goal of this study's facilitation.

In this case, the facilitation is aiming to bring together the different expertise of all participants of the group workshops and additionally the expert interview partner. the facilitation is meant to inform the different groups of each other's contribution. Additionally, in this study the facilitator is at the same time filling in the data and builds the bridge between the model and the data collection and specification. Through this facilitation process the participants are meant to gain knowledge about the model created and its usage.

Going through the model and understanding the principles of the model give important insights to the participants. They are learning the basic correlations and interactions of organic farming. The different alternatives of conventional agricultural are explained in the model so that the user automatically learns about the processes and options that are given by organic farming. To build that bridge between the tool and the user in future a facilitation is guaranteeing a better learning effect than just delivering the model to the users than integrating them in the process (Scholz et al., 2006).

Another important reasoning for facilitation is the mediation between different participants. Since social power relations are very strong in Ethiopia and especially in university contexts and the participatory modelling process needs to involve all facilitation aims to mediate between contrasting parties. That way all perspectives can be integrated in the participatory modelling.

Another point of attention of the facilitation in this case should be given to the model itself. The methodology of the model suggests a detailed understanding of the model – concerning the setup but also the single elements of the model. Therefore, the facilitator needs an expertise in the model setup.

4.2.1.2 The types of facilitation

Through the years of practiced facilitation different ways or types of facilitation have been defined. In this study some are screened and selected to understand the facilitation of this study better.

There have been lots of theories how to divide different types of facilitation in general and particularly in the development context. From a very intervening approach in the early stages of work in the southern hemisphere when the mindset was more radical. This time has been predominated by the perception that the northern hemisphere knew the way for the southern and revolutionary approaches like the Green Revolution have contributed to that picture. A technical innovation worked out being the only path that could be gone to feed the “poor”. That way a pattern established that has been predominating the scene of development work for quite a while. The facilitator – which was not called like this, but we use the term to draw a better comparison to the facilitators of today.

In the 1980s first participatory approaches revealed and facilitators were called facilitators the first time. In the early stages of facilitation, the facilitator was steering the participants or stakeholders somewhere. Later the facilitator took over a passive role and was meant to be observer. This approach is also not very feasible since it included a zero-intervention and since the facilitator has been there some sort of interaction even if passive has been there. Through this development, the definitions of facilitation developed in a more moderate direction. Nowadays, facilitation is integrated in most development projects. But the difference of today’s facilitation is a less radical definition of facilitation. The tasks of the facilitator need to be defined and can range from passive to total active interventions. Concerning Groot et al. there are two main divisions between facilitators. The ones are insiders and the others are outsiders but what they do in the end completely depends on the context. Insiders are part of the development of the problem that is going to be solved through the process. They either emphasize with the group or the problem by belonging to the group or a process of integration in the problem-solving surrounding. The outsider comes along with an external who’s aim it is to help the problem being solved in the interest of the problem solvers/participants.

As Groot et al. argues there are not only different types of inclusion in the facilitation process but there are also different styles how a problem is targeted. A division in reflective, instrumental and integrative is found in a lot of literature under different definitions or names. All definitions aim at a learning process to find solutions or pathways of a single problem or challenge (Groot & Maarleveld, 2000).

1. **Reflective facilitation**: The facilitator engages a learning process the group of participants. This tends to bring the participants to the state of self-facilitation with the cycles of reflection, planning, action and observing and reflection. This is called triple loop learning and tends to show trends and changes in subsystems of the problem statement.
2. **Instrumental facilitation**: Within this definition the facilitation is in a linear direction concerning a perceived problem with possible obvious solutions. This is a linear approach

that is product/outcome-oriented and faces less reflection processes but more analysis and planning.

3. **Integrative facilitation**: In this style, the facilitator needs to be competent concerning methods that highlights the perception of different stakeholder/participants to support a joint decision making process. A sub-type of this is the *distributive mediation* style which is a mediation where the facilitator pushes the interests of the stronger parties. The facilitator gets in a deal-maker role.

All types and styles have their own justifications but in reality, a higher complexity can be found and the practice always is a mixture of those styles. The awareness of the existing differences in facilitation is very important because it shapes the style of each facilitator. The context facilitation is taking place is defining which styles might be most successful.

In this study the mixture is dominated by the reflection and integrative facilitation. The aim is to settle ownership and understanding within the different participatory groups. By engaging them to share their knowledge – and this way fill the model – the model gets defined by them and is part of the participants' work. Methods are needed for integrating the local knowledge in an external system. This is exactly where the bridge needs to be build and where facilitation comes into play.

4.2.1.3 The facilitator

The facilitator himself is the link between project owners and participants. Within this definition there are several ways of interpreting this role. In the following it the key role and activities are defined of the facilitator in this study. The facilitator is aimed to steer the group dynamic process in a way that is defined to be successful. It is a prerequisite that he is non-judgmental and integrates the gathered information in the project – no matter if it is his/her opinion.

To get a better picture of what a facilitator actually is, three main sources have been consulted to check the validity of the projects definition. This is:

The Facilitator in this project is meant to guide and steer the participatory modelling process concerning the organic farm model. Within this process the facilitators' role is to engage interdisciplinary knowledge exchanges and communication. The facilitator in the group workshops and discussion to (1) function as neutral moderator and (2) to deliver input from the organic expert perspective when demanded.

After The Quality Assurance Company (Company, 2001) the facilitator is a "neutral and independent party who coordinates and facilitates interactions across the partnership between the different stakeholders". The facilitator convenes discussions between interest groups and multi-stakeholder so that neutral space is guaranteed for fruitful exchanges. With this definition, initial meetings are included with the different stakeholder between which the discussion needs to be facilitated. This way the facilitator can ensure better the meetings with the different stakeholders (Company, 2001).

Another definition found in the literature concerns the trainers'/facilitators' role changes within the process of facilitation. As soon as the participatory process starts the participants take over the role of the experts and answer the subject-specific questions. Meanwhile the facilitator "steers the process of the group work / workshop and makes sure that the prescribed methods are followed." (Groot & Maarleveld, 2000). In the later stage of facilitation, the facilitator develops into a role that guides the proposals for certain solution finding processes.

The picture of the facilitator gets more detailed and clear when the facilitation process is described in general concerning the handling of group dynamics:

- "a good trainer must have the ability to gove time and attention to each different personality and make a team out of a group of individuals which will work effectively towards a common goal" (Company, 2001)

- working In a team is a dynamic process that can vary in its dynamics – the facilitator is an active part of this process
- a facilitator is meant to tolerate disruptions, confusion, discussions and confrontations between participants
- the facilitator aims at participants' responsibility. The aim is not to intervene constantly but to engage in the motivation to participate. Total control cannot be reached by the facilitator.
- Nevertheless, the facilitator may not hesitate to intervene when it seems important and necessary

Basically, the facilitator has to adapt to the situation concerning five major issues or aligned at five levels how GROOT (2000) calls it:

1. **Environment**: Where you train? When?
2. **Behaviour**: What you do while training? (Within environment).
3. **Capabilities**: How you do it? (Strategy and skills guiding your behaviour).
4. **Beliefs/values**: Why you do it? (Motivation, permission, capabilities).
5. **Identity**: Who are you? (Overall purpose shaping beliefs and values through our sense of self).

These question, will be answered in the following chapters when reporting about the individual sessions and meetings. It might play an important role for the facilitator to better act and reflect on the actions and interactions. Since there is always an influence of the facilitator on the training/workshop/interview it is necessary to be aware of what the influence is. This way the facilitator can better estimate his/her influence on the participants. Patterns might show up later can be made transparent by the documentation of these five issues.

4.2.2 Gender

In the following section a general introduction will be given into the topic of gender and especially gender in the development context. It is explained how participation and gender are linked to each other and what the underlying principles are. In a second step the challenges of a *good* gender inclusion are described and potential solutions are offered to be integrated in this study.

4.2.2.1 Why gender?

Generally, the feminist research and the participatory research face and share the same epistemological, ethical and political principles (Maguire, 1987). In the African cultural context, these principles are integrated in the ethical understanding and structures of the society. These percolated through up to an embeddedness in the political principles and patterns how the politic functions and interacts. In this political context, the question that rises are connected to the agenda of such political institutions. How can a pre-shaped development agenda integrate the gender issues in a way that the individual and situational challenges concerning gender can be tackled adequate; (Cooke, 2001).

When talking about participation often Participatory Rural Appraisal (PRA) is one of the major examples used. PRA as equivalent for participation in a planning or modelling process – like it is in that case – is often conflated with "doing" participation. Participation in general might seem in first instance to do a lot of gender work since it is meant to integrate all diverting perspectives (Robert Chambers, 1991).

But it is important to realize and know gender is not part of participation as such (Cornwall, 2003). It might even be the opposite and tend to emphasize formal knowledge and activities and, that way, reinforce the invisibility of women. The base for the relation between participation and gender is a neutral one. This relation is not self-explanatory but is often assumed by organizations and different stakeholder. Who does participation in a project does at the same time gender. This assumption is not true as it strongly depends on the project and its team, stakeholders and purpose (Cornwall, 2003).

The most projects in development cooperation run according to a certain technique that structures the use of methods. The technique have a certain mindset for different topics that they are tackling. Goetz states that in projects and policies, the implication often is found that "the technique used can override forms of prejudice embedded in organizational cognitive systems and work cultures" (Goetz, 1994). The technique itself doesn't define how certain social and cultural issues are tackled or integrated but the team is of higher importance. There is a strong dependency between the team that engages in the participatory approaches and the inclusion of women. Cornwall points out two major reasons for a missing gender focus in participatory projects. One is the lack of female staff and the second one is connected to the failure of anticipating the gender awareness (Cornwall, 2003).

4.2.2.2 Challenges and chances of gender in participation

According to *Cornwall*, women in the development context still face old paradigms that challenge the inclusion of the female perspective (Cornwall, 2003). In development, the usual practice needs to be defined in a model that fits for several cases concerning one issue – in our case the gender. The crucial point of those models is that they mostly lack many of the nuances of the analyses from which they are derived. That ends up in a so called "doing gender" (Cornwall, 2003).

The topic gets even more complex regarding the inequitable relations between women in gender issues like inequality in HH and domestic work, education, criminality, etc. There has been done research about these issues and often these interferences are argued to be matter of consciousness. That way these differences tend to be neglected and diminished to a way more unimportant topic than the relations between men and women (Cornwall, 2003). Changing the structures and perception of gender can have a crucial influence on the structures of property and endowment (Meinzen-Dick, 1998). That way new discussions can be triggered when intervening in a social framework that is not fully understood. When including gender considerations in a certain topic, the need for a holistic realization is important even though the task here is not to solve the challenges originated in that complexity (Cornwall, 2003). This means that in a participatory project including a gender perspective it is even more important to integrate an analysis of the whole system. The understanding of the small relations and interlinkages. Only if that is guaranteed a project can enfold its power for an impact that evolves in the implicated way.

Several reasons are designated by men and women to explain gender inequality. Women associate the reasons for inequality in: poverty, stigma, high infant mortality and HIV infection rates. These leads to disadvantages for women and their community contribution. Combined with "ignorance, illiteracy and the traditional culture", women state their perspective as structurally – politically and socially – unbalanced (Wiliams, 2014). Men see different reasons leading to inequities between men and women. For men, the inequities are located more in a political disposition: beside the female attitude, the lack of governmental support, responsibility issues and the suppression of women, and the low level of development in Kenya results in the inequities. The bias of these argumentation is therefore mainly based on the formal structures where men find partial justification for gender gaps. A formal structure which promotes men – in a system overlapping manner, including education, domestic workloads, the role in the family, etc. Even though in Ethiopia the legislation gives men a higher level of freedom to act and explore. There is an active women movement in Ethiopia but this has not yet stroked the rural areas.

That gender "can disempower if it removes the ability to control the dissemination of knowledge" like Cornwall states puts attention to the follow up and the consequences of a triggered gender discussion. With gender balance in a project it is important to prevent the discrimination of women after the project finalization. The knowledge that has been gathered in such a project and the status that women have can provoke older social patterns and therefore be denied.

Stakeholders create awareness for this topic by participating in such a project. These influences are not ensured to be positive and that way the dissemination of the knowledge that is gathered out of such a process needs to be handled with care. This is why stakeholders' discussions need a facilitation. (Cornwall, 2003).

Normally, in cases like the one described in this study the involvement of people reduces after the first motivation. This has several reasons which are not discussed here. The important phenomenon to underline is that involvement of certain parties implies the involvement of even more interests. For example, if in certain cultural circles women do not show up in a meeting, this does not equal a non-influence. Most of the women which are invited to join participatory projects inform themselves about the outcomes of meetings. Women that want to have an impact but are not going to meetings also give some indications about their interests to their men (husband, partner, family member) who are joining the meetings. This way, women interests are infiltrating male dominated meetings (Long, 1989). Following this practice there might be a discussion necessary about the representation of women interests and if men are able to substitute their women concerning their interests.

Agrarwall takes several constraints that are familiar in the debate of gender equity as base: time, male bias, women's capabilities and roles, lack of public experience (Agrarwal, 1997). A huge impact on this factor has the education and training for women. Including women in trainings with extension workers concerning a certain topic already empowers women and teaches them how to interact in groups and represent their interests.

One major factor described in the literature through the decades of development work is the mindset and the orientation of an agency or organization. As stated earlier, women are still participating in an informal way through their husbands and other men that represent their interests. In cases where women feel the direct impact of a meeting or an assembly, they will find the time and make the effort and join this meeting. This leads to the conclusion that the value concerning the judgment of the advantages and direct impacts of an organization can be determined by the presence of the female parties (Meinzen-Dick, 1998).

Participation processes tend to be as gender sensitive as their facilitators. (Cornwall, 2003)

Linked to this, a phenomenon is often found when it comes to the implementation of certain gender-related measures, which consists in seeing as gender representatives the women engaged by an organization. These women can have totally different tasks or T.O.R.s, but as soon as the debate focuses on gender, the women present are identified to represent female interest (Cornwall, 2003). Particularly female networks and organizations are of high importance. Only through an institutionalized structure where the participation of women in focused on can help to prevent that actual phenomenon regarding women interest inclusion (Meinzen-Dick, 1998). If women have the opportunity to join a certain organization that is represented on higher levels the women easier can introduce their opinion and their interests through this organization. That way the perception of these interests changes from a 'women interest' to an 'organization' interest'. It changes from an individual interest to a community interest. This has proven to be more accepted in the political debate.

5 METHODS

5.1 Overview

The methodology of this research is based on participatory methods that give the research its framework. As displayed in the figure below the framework is based on the concept of participatory modelling (Binot et al., 2015; Jones et al., 2009; van Eeten, Loucks, & Roe, 2002).

The planning of a model farm for organic agricultural practices and social innovations in the agricultural sector is based on a model that calculates with the figures and specifications. Since the aim of this model is to adapt to all sorts of agricultural circumstances the case of Bahir Dar will be a show case that is meant to be scaled up to different regions in Ethiopia. After evaluating the model, the question, how far a model can help to define and fit the agricultural, social and economic realities a model farm is facing, can be answered more precisely.

In the following the methodology of the participatory modelling will be explained and defined. This participatory modelling provides the frame for the modelling process and all involved practices and stakeholder and correlated dynamics.

Primarily, a stakeholder analysis is crucial to get an overview of the diversity of interests and perceptions into a model farm. Due to the fact of a close linkage to the University of Bahir Dar a certain predefined circle of potential stakeholders is set. Proximate, the participatory planning will deliver data like calibrations and parameter for the model that is parallel developed. The academic groups *organic advisory group, gender* and *farmers* are delivering parameter for the model that is parallel developed in individual planning sessions and interviews. Involved in the development of the model are mainly experts of the fields organic farming, water management, irrigation, topography and gender & sociology. This group of experts include academics, NGOs, governmental organizations and experts of private organizations. Out of this a prototype of a model farm will be created. At the end of this participatory modelling the academic groups are asked to evaluate the model. According to the outcome of the evaluation adaptions will lead to a final version of the model.

The methods will follow according to the conceptual framework of participatory guidelines (…). Different stakeholders such as farmers – conventional and organic –, students, the ministry of agriculture, farmers' associations, future project owner(s), potential partners, etc. are asked to bring their inputs into the conceptualization and modelling of the farm. This happens through different workshops, interviews and participatory observations by the researcher. The information will be gathered first stakeholder-group-wise to ensure a maximum of openness within the different groups. The members of different groups might not be comfortable sharing their opinion with other groups. The setting must be one where hierarchical cultural and social rules are not able to hinder or manipulate the information exchange. Through Ethiopia's culture the risk is increased that in a setting where all contributing parties are brought together the vision and information of the most powerful member attending will be predominating (R. Chambers, 1998). Therefore, a separated collection of information in specific settings and data is necessary to ensure the inclusion of the individual stakeholders' perspectives. To identify the different stakeholders a *stakeholder analysis* will be done to ensure the inclusion of all different stakeholders. For the participation a stakeholder analysis is a crucial element to integrate all perspectives, interests and challenges (Hinrichs, 2014). In the beginning phase this might conclude in a more time-consuming preparation phase. But in the long term perspective the integration of all interests or at least a negotiation between the differences ensures a higher sustainability of the project itself (Hinrichs, 2014).

As displayed in Figure 2 different methods and approaches of the "PRA-family" (Participatory Rural Appraisal) are used. This modelling plan is not linear but different methods can be used simultaneously. The detailed methodology will be explained in the following chapters. It is crucial to understand the set of methods as a whole. The separation of different methods would cause gaps in the information chain and the completeness of the necessary data.

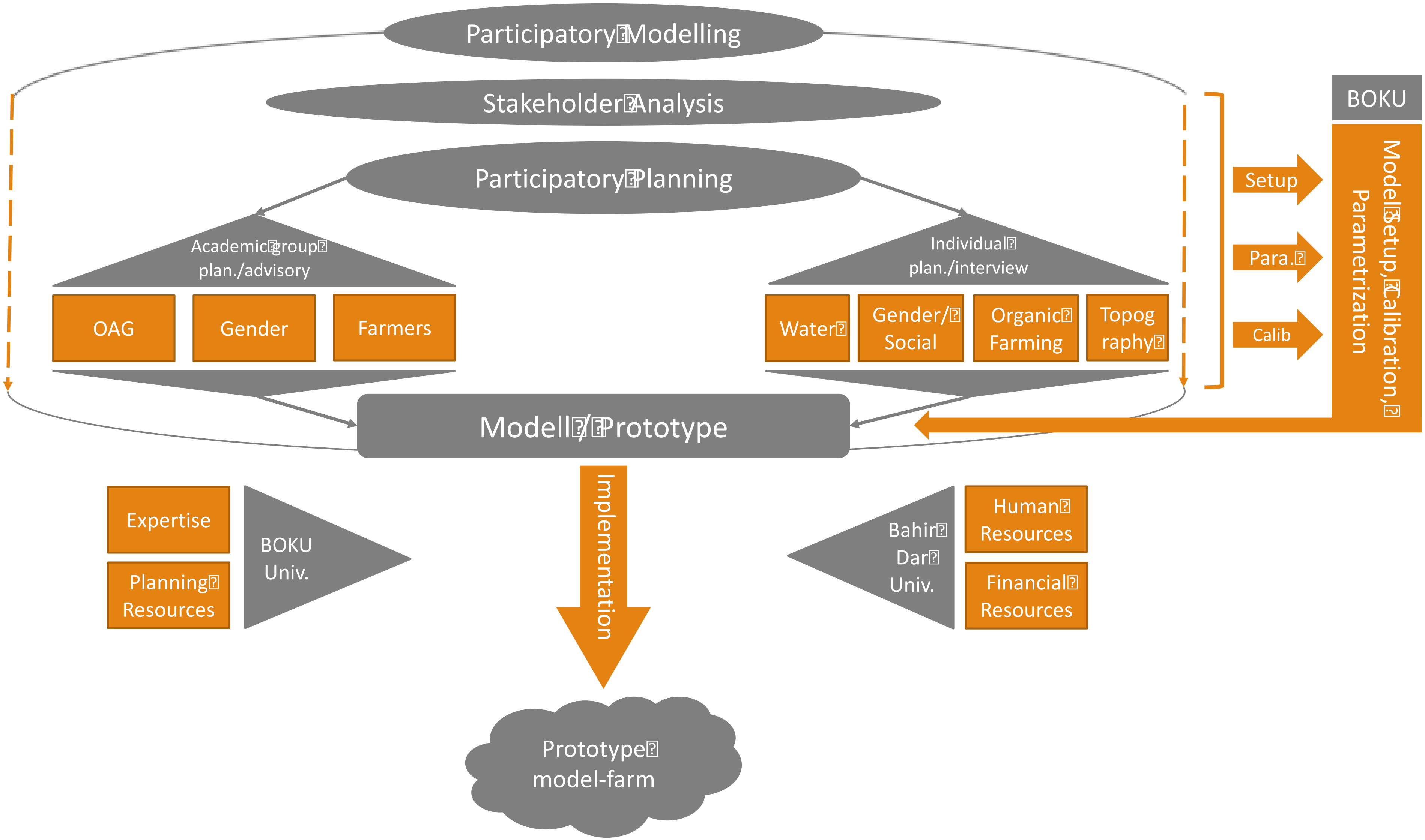


Figure 2: Concept of the participatory modelling process

5.2 Participatory Modelling

5.2.1 Introduction – Why Participatory Modelling

"Participatory modelling promotes the co-generation of solutions among different types of stakeholders and takes account of uncertainty and different knowledge bases including local knowledge, expert or specialized knowledge and strategic knowledge, the latter being concerned with the processes of developing governance and alliances."(Jones et al., 2009, p. 1181)

This part of the chapter introduces participatory modelling as a method to engage stakeholders in a co-creative process from the beginning of any project onwards. The idea of using a model to display the complexity of the reality or a specific problem involved is the base for a better implementation of a project. The participatory modelling approach was initiated based on IT-programs that tested the usability of certain models in the reality. To understand the total complexity of a system – here the one that the project is implemented in – it is necessary to integrate the different disciplines and local knowledge to model in a certain detail that ensures later higher resilience.

Participation through the years of development cooperation has become an accepted method of project management. In participatory modelling approaches a facilitator has the role to bring certain stakeholders, interests, disciplines and groups together and guide a co-creative modelling process. The extent of the facilitators' guidance need to be adapted depending on the projects' conditions. Key concept behind the approach aim are:

- Integrating the local knowledge and creating engagement of the stakeholders
- Ensuring the understanding of all stakeholders concerning the context

In this particular study the participatory modelling is used according to the second type of participatory modelling following (Robles-Morua, Halvorsen, Mayer, & Vivoni, 2014). This second type of modelling "model setup, parameterization and calibration" is majorly base for this research regarding several stakeholders. Beforehand, the model is defined in cooperation with several experts concerning organic farming, water management and agriculture. The underlying principle for a good cooperation is trust. The facilitators task is to work on this base the co-creative process. This starts already concerning the cooperation of individuals. To gain an open and honest interaction of between facilitator and experts it is important to respect and value the perspective of all – at that particular state of the process – experts.

The embedded mindset of participatory modelling in this research is based on system theory. To understand the individual elements of a farm and their interaction, complexity system theory offers the right framework – called participatory system dynamics modelling according to Stave (Stave, 2010).

Concerning the key challenges, the approach of participatory modelling faces criticism due to the paradigm shift of the work in developing nations. The lack of information transport is a criticism rooted in the old paradigms but reminding the project about the focus of non-extractive knowledge use of local communities (Robles-Morua et al., 2014; Voinov & Bousquet, 2010). The stakeholders involved create a limiting factor because the project owner decides what a reasonable number of disciplines and stakeholders is (Robles-Morua et al., 2014). Out of this number of stakeholders involved it might easily happen that the knowledge transfer is lacking depth. Still, in the main focus is the freedom to decide on their own and integrate in the system the knowledge that appears to be important for system insiders (Mendoza & Prabhu, 2006). Trust is a very important prerequisite for the functionality and engagement of the participants. If trust is not given the participants tend only to do lip services and advise, or guidance will not be integrated in the participatory process (Cleaver, 1999).

5.2.2 Theory

In the past resource management and planning processes have been entrusted to experts and well-educated researchers and professionals who then had high influences on local systems were not part of (Mendoza & Prabhu, 2006). Communities and local stakeholders have been involved in very low extent. Since some years the participation in planning processes increased because of the local knowledge that is automatically integrated in the planning when including those stakeholders. It has been argued that a sustainable resource management and planning is not able to be completely understood by system externals. These planning methods driven by external experts have been declared as ineffective and unable to address the local challenges right (Jones et al., 2009; Mendoza & Prabhu, 2006; Robles-Morua et al., 2014; Stave, 2010; van Eeten et al., 2002). Participatory modelling which is part of participatory management has been widely accepted as an "appropriate and effective paradigm particularly in the developing nations" (Mendoza & Prabhu, 2006). A process like this would entail the help of the participants for structuring the problem, describe the system, create an operational model of the system and find its parameters and finally test the model (Stave, 2010).

Even though the participatory modelling is one of the very diverting participatory methods there are fundamental similarities in "…their general processes and the nature of issues and problems they are designed to address…" (Mendoza & Prabhu, 2006). This includes the vision of multiple stakeholders and their interests and the empowerment of local stakeholders. In the literature, the conclusion is that participation is a prerequisite for active involvement in the planning, decision-making and actual implementation (Jones et al., 2009; Mendoza & Prabhu, 2006).

It (participatory modelling) provides a mechanism for integrating scientific knowledge with local knowledge and building a shared representation of the problem. (Stave, 2010, p. 285)

5.2.3 The idea of participatory elements

The idea behind this concept is an integrated modelling (planning) process. Its roots are located in gamification (IT) approaches. Participants are engaged to develop a certain model with the guidance of – in this particular case – a facilitator, collecting the data and merging them to a suitable model. The order like displayed in Figure 2 is suggested to be follow to achieve the aimed results. This approach of creating a suitable model enlarges the amount of disciplines and perspectives integrated. The researcher or facilitator has to decide about the amount and size of the participating groups, individuals, disciplines and interests. The more participatory elements are involved the higher the complexity. A higher complexity is not something that has to be avoided but a certain reasonability needs to match with the practicability of handling the complexity. The increase of participating elements to a certain extent increases the resilience within the context of …of the project. Reasonable in that sense describes the boundary when additional elements/criteria do not lead to any further increase of knowledge or resilience (Jones et al., 2009).

5.2.4 Internalizing decision making processes

These approach has been proven as an important tool for conceptualizing the inherent complexity of natural systems (van Eeten et al., 2002). Different labeling refers to cooperative modelling, collaborative modelling, mediated model-building and so on. The basic idea behind the concept is the shared construction and setup of a model that displays a certain complexity of a natural system, like an organic farm. In the setup of a farm it engages the collective decision making process that entails the engagement of the participants. No external institution takes the decision and that way the internal ownership of participants is triggered even more. "…by gathering and integrating diverse participant knowledge and viewpoints and building trust, a collective vision can be created and adapted to changing conditions." (Jones et al., 2009; Robles-Morua et al., 2014, p. 275). The strongly transparent and participant-steered problem definition and the dealing with the issues and problems create the strength of this approach (Mendoza & Prabhu, 2006). Through this, social learning is a major advantage since the users or participants can experience and learn about the system and its connections (Stave, 2010).

5.2.4.1 Types of participatory modelling

In general, there are three different types of participatory modelling.

1. The “model development” is dealing with the issue of selecting an appropriate model for the researched problem. In the following it deals with the calibration and parametrization of the model.
2. The second one is the “model setup, parametrization and calibration”. This kind of participatory modelling deals with the setup of a certain model that has been chosen before. This is the type of participatory modelling that gets the closest to this case since the borders between the type dissolve in the real implementation of the methodology. The model will be chosen and created by experts and in a later step constantly counterchecked with the local perspective and knowledge. Only in a crucial separation of opinions between experts and participants the model will be changed.
3. The third type of participatory modelling is the “model output analysis”. The model is already setup and the participants are asked to review the model and its inputs to test its results. Adjustments can be made by the modeller – in this researcher it is at the same time the facilitator – but the extent of the integration of the participants’ perception is up to the modeller.

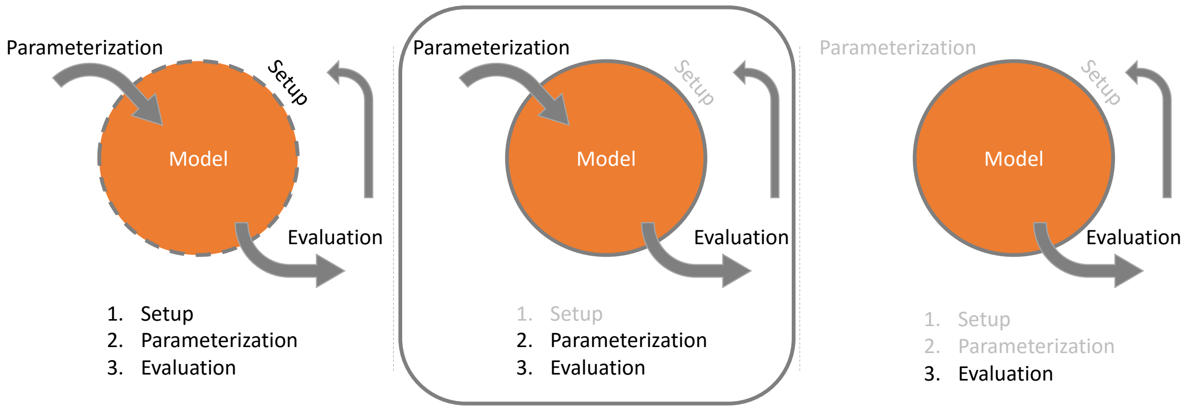


Figure 3: Types of participatory modelling

Type 1 (left): Participants involved in Setup, Parameterization & evaluation
Type2 (middle): Part. Involved in Parameterization, Evaluation
Type 3 (right): Part. Involved in Evaluation

Other types provide the participants more freedom to integration their perception and in an ideal case the model entails only parameters that are parts of the participants’ knowledge and perception (Robles-Morua et al., 2014).

The aim of using participatory modelling is actually to strike four major themes at once that hardly can be integrated alternatively and often lack a modelling process (Jones et al., 2009):

- to integrate and improve the understanding and the complexity of the organic model farm
- to use and integrate the common and local specific knowledge of the participants (Voinov & Bousquet, 2010)
- to enhance interactions and dialogue between participants in order to create a base for collective decision making and establish a collective base of knowledge (Voinov & Bousquet, 2010)
- the creation of space for exchange, common knowledge and collective action (Cleaver, 1999)

- to structure group analysis of a problem – whether it is conceptual or operational (Stave, 2010)

5.2.4.2 Managing disciplines

As representatives of larger communities the participants need to be selected before the actual modelling starts. This is a constraint to better emphasize which knowledge and expertise is covered by a specific group and gives indication about the necessity of creating different additional groups. Even though a group might cover more than one discipline it is useful to separate certain subject from each other. As Jones et al. (2009) argues it is reasonable to separate participants according to disciplines that have controversy or independent expertise. Nevertheless, in the modelling process it is important to give an indication about the overall state about the contributions of other groups. All participants of all groups need to be involved and updated so that the different members of different groups have the same knowledge about the state of the model. This is one reason why participatory modelling delivers a more engaged participation. All participants know about the whole model and its different elements (Jones et al., 2009).

5.2.4.3 Trust

How far participants trust in a model "depends on who designed it" (Robles-Morua et al., 2014). The aim to transfer knowledge from experts to practitioners mainly implies the knowledge about the usage of such a model. In classic modelling processes experts are needed to adapt, calibrate and interpret the model (Robles-Morua et al., 2014). In this particular study it is meant to empower the participants to use the model in their own interest and the projects interest. The model includes knowledge that is gathered from different groups and experts and through this entails diverse information that cannot be gone through within the modelling process. The model is additionally meant to accumulate the knowledge of the different groups that than can be interlinked – as far as this is not done in the model itself.

5.2.4.4 System understanding in participatory modelling

In the following the participatory modelling will be linked to the theoretical framework of system theory. The different relations between certain elements of a system can be better understood by experiencing their relation in a model.

As Stave (Stave, 2010) stated in *Participatory System Dynamics Modelling for Sustainable Environmental Management* a participatory modelling process finalizes in the definition and picturing of the system and its correlations and interrelations. The dynamic patterns generated and through this leverage points can be identified to clarify the potential entry points for adaption or change (Meadows, 1999; Stave, 2010). The identification of the system with all its elements is the first step. When the interlinkages are created and problematic issues are known the leverage points come into play and can help to tackle the potential problems. This way a resilient system can be generated through modelling. The key in this approach is that the participants get to know the system and its complexity and understand where and how potential changes can succeed or not – and why (Stave, 2010). This generated great advantage in the modelling through the potential of problem solving "beyond model output and irrespective of whether or not a decision is implemented" (Stave, 2010).

5.2.4.5 Setting and the Model

The need for a modelling approach is described by Mendoza (Mendoza & Prabhu, 2006) regarding the fact that in participatory processes the scope is broad and there are potentially large numbers of alternative outcomes. To filter those alternatives and broad options that are provided by the participants and the different influences modelling offers a framework.

Best practices of participatory modelling show that small groups are the most effective – including all participants in the process. The transparent modelling process and flexible planning are constraints for the project initiator. But it is of crucial importance that the participants are involved in an early stage of the modelling regarding the type of participatory modelling. In this case the first step is to decide for a certain way of modelling before the participants can give their inputs but after this definition process it is to engage the external participants to be involved in the modelling process.

In the chapter *State of the Art* it has been discussed which categories of different models with which functions there are – LP (PMP), SD, ABM. Now the question to be answered where this model is aiming to settle and what are the expected outcomes of it or the different processes that are aimed to simulate. This case sets the framework of organic farming meaning that the application of a model needs to fulfill the standard of organic farming concerning the holistic analysis. The different subsystem are interlinked and influence each other in – positive or negative – feedback loops. The second constraint this study puts on the model deals with the level of application. In this study the model is asked to simulate processes on farm-level taking closed-loop as underlying baseline. Additionally, the modeler or the group of modelers needs to be flexible and adapt the different circumstances on the farm. This is including the rational and linear characteristics of LP to model the outcomes and clear numerical indicators. Additionally, it is needed to take the holistic perspective of SD into account. The understanding of a system with all relations and elements is necessary to sketch a farm in total – even though these feedback loops are assumed to be linear. SD is integrating a certain set of social influences guiding decision making in the model. These are excluded in this study. The decision-making process is accompanied by the different informants/experts and groups. Nevertheless, it is off crucial importance that the model is validated and evaluated throughout the process.

5.2.4.6 Challenges

In the following the challenges of participatory modelling are discussed in detail. The information transport from experts to practitioners, the selection of participants, the missing structure and action plan, the trust and the evaluation of the modelling process and the involvement of less educated people are major challenges. The facilitators, participants and practitioners need to focus on these topics to minimize the possible negative impact.

A major challenge concerning the use of participatory modelling approaches is the criticism that the approach leaks information transfer – mainly from expert to practitioner. Despite the recognition and spreading of the practice it is argued that "…important knowledge gaps remain regarding the impacts on participants." (Robles-Morua et al., 2014; Voinov & Bousquet, 2010). Important to prevent this problem is communication and the right settings with enough space for knowledge exchange.

Despite the selection of the participants of the modelling and its preparation there is one concern that hinders a participation of all important stakeholders. The modelling process as such – in the university context – is limited to an international contribution of university members. This is a constraint of high importance because the end-user is through this limited on a higher educational level (Robles-Morua et al., 2014). The model will display local knowledge and information to the extent of the awareness of the participants. To extent this knowledge and information to a maximum there are several participating groups that are meant to cover all issues from agricultural practice to social innovations.

A third major criticism evolves out of the debate around the assumed lack of "rigor, structure and analytical framework" that a participatory process is apparently leaking by definition. It is a matter of fact that a participatory modelling process might leak specific information that is entailed by the project owners' perception (Mendoza & Prabhu, 2006). But once loosened from that paradigm the advantage of integrating more disciplines and covering a broader knowledge base fits more accurate to the context of modelling in and with developing nations. Potential detailed planning is more likely in such a context to be ineffective since the implementation surrounding is volatile and often fluctuating. Therefore, the effect of planning in a context with widespread coverage of disciplines might be more suitable and creates more resilience (Jones et al., 2009; Robles-Morua et al., 2014).

Concerning the finalization of the modelling process operationally there is a one-time chance for the participants. A participatory approach like the participatory modelling implies the active involvement in planning and decision-making giving the participants the responsibility and freedom to have real impact with their knowledge and contribution (Mendoza & Prabhu, 2006).

Additionally, the participants of former participatory modelling process show concerns about the trust building within different participating stakeholder. To ensure the trust and an open discussion definitely belongs to the facilitators' responsibilities. A weakness of this approach is the missing research about it. The need to create a "new language" between the participants demands high facilitators' capabilities concerning the understanding of the system and its possibilities (van Eeten et al., 2002).

On the other site it has been observed that in too many cases stakeholders have committed verbally to a project but their engagement in the later process has then been nominal (Voinov & Bousquet, 2010). To tackle this problem, the understanding of the involvement of stakeholders and their motivation is prerequisite. Often stakeholders are motivated by short term financial advantages or the involvement in an acute project. As soon as the project is done or the project owners disappeared the stakeholders are involve in different projects. This struggle in development processes are known since long time and the long term progress or sustainability of projects in the development context are challenges that force the development cooperation into new methodologies (Cleaver, 1999). Therefore, it is important to pay attention to the way of implementing a project and selecting the stakeholders (see Stakeholder Analysis).

Former participatory modelling research additionally taught a major lesson in the evaluation of those participation. Participatory modelling asks for the integration of participants in all stages of the process – planning, implementation and evaluation. The evaluation often is a neglected issue but needs to be integrated under any circumstances to tackle the following issues:

- "Capacity to better integrate local authors in a collective decision process." (Jones et al., 2009)
- "Influence of project designers upon the process and outcomes" (Jones et al., 2009)

5.2.5 Participation

5.2.5.1 How to facilitate?

Screening the literature, the best practices of how facilitation is done according to the standard and the definition of facilitation there are plenty of case and guidelines. For this research a certain framework for the facilitation has been created and is in this chapter counterchecked with the literature.

5.2.5.1.1 Rapport

A main issue concerning the facilitation is – as found in all literature and case studies – the process of rapport building. This process is about the trust and relationship between the participants themselves but mainly between the participants and the facilitator. This relationship needs to be established in a good manner that the openness to listening, influencing and being influenced is ensured. As the facilitator in the case of rapport knows what is real for the participants and what matters so that the facilitator is able to meet the participants but also the joined goals of the process. Missing rapport can lead to the perfect training that the facilitator imagines the participants want to have but is missing the necessary link to the participants' needs and interests.

In the figure above the relationship of participants and facilitator is displayed. The optimal stage in a participatory process is the balance between the difficulty of the task and a high relationship between all people involved. The task needs to fit the abilities and capabilities of the participants. Regarding the relationship of the participants and the facilitator its increase only improves the outcome of the participatory process (Groot & Maarleveld, 2000). Basic examples for the understanding of this correlations are:

- **Presenting**: high task & low relationship
- **Training**: high task & high relationship
- **Moderating**: low task & low relationship

In this study the task and relationship correlate in an extent that comes close to the Training situation. Concerning the cooperation with different local stakeholder groups to fill the model with data demands for understanding and cooperation between the group members themselves and the facilitator. For the expert interviews and cooperation on the model it also is important that the facilitator and the interviewee have a base of trust and openness to mention and discuss the process openly.

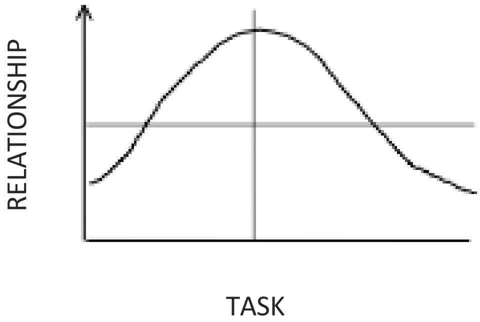


Figure 4: Relationship & Task (Groot & Maarleveld, 2000)

5.2.5.1.2 Setup

The facilitation in the study is meant to be non-judgmental concerning any contribution of the participants. There is expected to be a guidance regarding the content in the participation. On one site there is a clear information gap that is aimed to be filled by the participants. Therefore, a steering of the participants is required. Nevertheless, there is another site including issues like the finding of innovations and evaluation of the engineered tool. Concerning those topics, the participants had no guidance and were asked to work in groups to engage in the exchange of ideas.

In the following, there will be some remarks on the way how to reach a good facilitation process in this study – these will also be dealt with in the chapter methods:

- Understand the viewpoint and educational level of organic farming of the participants
- Review and synthesize the viewpoint and knowledge of the participants from a perspective of the facilitator (here with a precise aim of filling the model with local data), and out of an independent observer
- Look at the situation of the group out of an optimist, realist, critic's perspective
- Identify the possible information, knowledge, input and process the groups might be likely to profit from – concerning the aim of the different groups
- Be aware and if needed train the group in the key principles/issues on which consensus is a must to secure the participatory process
- Establish, outline and time-frame the participatory process

The main aim behind the participatory part of this study is to envision the interests of the participants and let these be displayed and integrated in the designed model

5.2.5.2 Challenges & Chances

In the following certain challenges are discussed that facilitation is facing. The argument come from different directions and parties. As well as facilitation critics as facilitators explain challenges that might not be case specific but found in all processes. …

The major challenge and chance at the same moment concerning the facilitation of potential projects is the personality of a facilitator. Whoever facilitates a projects brings his own mindset, background and personality. The question of which tools and methods the facilitator is able and willing to use needs to be analysis in the context of personality. This personality might vary strongly from case to case so a facilitation never can be the same twice. The individual actions and reactions cannot be reproduced. It is important to understand the personality and the motivation of a facilitator in a project like this study. Like Groot et al. explain the responsibility to train and equip the new generation of facilitators lays with the institutions. The whole profession is new since the facilitation is not anymore practiced in the straight project management ways with a clear outcome (Groot & Maarleveld, 2000). A lot of flexibility and the ability of adaption is prerequisite for this profession. To prepare for this new professionalism institutions, universities and organizations are suggested to invest in the education of "agricultural universities, colleges and other organizations and networks" (Groot & Maarleveld, 2000, p. 16).

Another challenge deals with the perception of the facilitator. Every facilitator has a background, opinions and perception. This way it is difficult to measure or preset the behavior exactly in a facilitating case. It is therefore important to define certain rules of behavior and framework the aims of the facilitation. It needs a reflection itself before, meanwhile and after the facilitating process. A constant reflection on the own motives and actions sharpens the facilitators' perspectives and influences his/her actions. Therefore, it is important to define a kind of tool to support the reflection of the facilitator. This can be done through a research diary or sparring sessions with other system externals (…). In this study the facilitator creates after every meeting a research diary to capture the developments and tendencies of each interacting group.

In this study the challenge is to divide the role of the facilitator and the engineer properly since it is the same person. The facilitation is about a learning process and not about content. But in this study the urge for the content is preset by the methods that are used to gather the necessary data for the model to function. Within this bias it the facilitator is challenged to find a balance of content and process in the moment of facilitating.

5.2.6 Potential Tools Applied in Participatory Modelling

The method of participatory modelling entails a wide range of possible used sets of tools. The methods itself depends on the interaction of different stakeholder which first have to be defined to be integrated. The modelling process in this study is to be conducted in interactive groups. Therefore, it is necessary to integrate participatory observation since the researcher is the facilitator in the workshops. Additionally, in the process of modelling there are different experts consulted and interviewed. In the workshops it is helpful to have a set of participatory tools on the hand – e.g. *Participatory Mapping, Participatory Diagramming.*

5.2.6.1 Stakeholder Analysis

Through the years of development work stakeholder involvement has grown to a "must" (Voinov & Bousquet, 2010). The sector of participation in the development context grew through the years of development and has become a significant part of cooperation that the importance of who is involved is about to be focused on (Cooke, 2001; Voinov & Bousquet, 2010). In the 1990s stakeholder analysis has been introduced to projects to better meet and match with the stakeholders interests. Local people were meant to profit from those projects but interaction was missing through that the outcome of the project was useless. Stakeholder analysis therefore offer a tool which helps to identify and resolve the trade-offs and conflicts (Robin Grimble & Chan, 1995). Additionally, it helps structuring the different disciplines to give their contributions and merge them in one complex system.

Characteristically the stakeholder groups cut across society. The aim is to integrate all sorts and ranges of groups with e.g. formal and informal settings and to tackle sensible issues like gender balances. The aim is in that context to picture a problem holistically and see its complexities and potential conflicts.

There are two ways stakeholder analysis is contributing to a better understanding (Robin Grimble & Chan, 1995):

1. **To improve the project concerning its selection and design**: the projects' horizon gains more wideness when integrating the perspectives of actual involved people/stakeholder; and at the same time the conceptualized framework is constantly approached.
2. **To better manage the impacts of a research project:** all contributing parties are meant to take something out of the project. Through the stakeholders, the outcome is easier to get to the actual beneficiaries through (1) the close link between the representative stakeholders and (2) the project interests being influenced by the same stakeholders.

Behind the stakeholder analysis there is the concept of understanding a system and "for assessing the impact of changes to that system, by means of identifying the key stakeholders and assessing their respective interests." (Robin Grimble & Chan, 1995, p. 1). The differentiation between the ones that **are affected** and the one that are **affecting** is crucial in this context. A clear picture of the interlinkages and their results is given through a clear understanding of the system as whole with its interactions between the different stakeholders.

The stages that need to be ensured by the research and the method of stakeholder analysis acacording to Grimbie are (Robin Grimble & Chan, 1995):

1. Clarify objectives of analysis
2. Place issue in a system context
3. Identify decision-makers and stakeholders
4. Investigate stakeholder interests and agendas
5. Investigate patterns of interaction and dependence

Reading these step already shows the complexity of understanding the involved parties and their diversity.

For the collection of the right data it is necessary to identify first the most important and influential key stakeholder. Criteria for stakeholder are developed with the local project partners to find the right set of indicators that mark certain potential stakeholder (Grimble & Chan, 1995). For this research together with researchers and experts it turned out that the following stakeholder need to be integrated in the process. Furthermore, in the modelling process not all stakeholders might be needed in the same extent of involvement:

- Bahir Dar University
- University of Natural Resources and Life Science Boku, Vienna
- Experts (Water, organic Farming, local knowledge)
- Smallholder farmer
- Organic farmers/farms
- Representatives of local communities
- Representatives of Ministry of agriculture
- Farmer/water user associations (depending on the location of the farm)
- Representatives of local government
- Future project leader and project team
- Additional MSc- / PhD-students

These parties need to be included in certain ways and extends. In how far the inclusion needs to take place in the first concept-phase has to be determined in the process. It is assumed that the stakeholders in bold are the ones to be involved primarily, since most other stakeholders are required for later administrative purposes. Certain stakeholders are of more urgent interest than other in the conception phase. Nevertheless, the communication between these different interest groups need to be established as soon as possible to settle the feeling of ownership and involvement in an early stage of the project.

5.2.6.2 Participatory Observation

Participatory observation, as a common measure to gather data in ongoing projects, is used to be part of the group and additionally collect the information of the different workshops. Through the participatory approach the researcher is building trust with the participants. Through this more detailed information is share by the participants in a trustful space. The information observed and gathered is kept through the OAG diary which is written by the researcher after every WS. This includes information that has been communicated but also interpretations of gestures and acting of the participants.

5.2.6.3 Interviews

Concerning the fact that some stakeholders are individuals –and not only representatives of their stakeholder group – and particular information is needed, interviews will contribute to a focused information gathering. The context of those interviews is a political and administrative one. Interviews with different administrative institutions and governmental bodies will provide insight about the legal framework and political situation for a potential farm, but also collaborations with the surrounding farmers. The interviews are meant to create interaction with the local authorities to ensure a communication within local administrative forces, i.e. with the local authorities. Furthermore, the stakeholder analysis will bring up additional stakeholder with interests concerning the pilot-farm so that there is the chance that there might be other parties which need to be interviewed.

The interviews will integrate questions quantitative a certain issue to ensure the fulfillment of local rules and regulations and gather certain facts and figures. Additionally, qualitative parts of the interviews will show the understanding and give more insight concerning the interviewed parties and their perspective on the project. There will be different interview surveys for the different stakeholders since they are interviewed concerning different fields of experience and expertise.

Concerning the right application of interviews, it will depend on the size of the interest group if it is of use to integrate participatory methods or not. With individuals and stakeholders that represent a certain framework with clear outlines like the legal framework it might be more useful to integrate the mapping and diagramming in a particular set of interview. That way the important information is ensured to be gathered and additionally there has been contribution to the participatory methods.

5.2.6.4 Participatory Mapping

Based on the participatory approaches methods like *participatory mapping* include the locals' perspectives concerning divers issues. But also, the other interest groups are in that way able to express their ideas and concerns. In the research, it will be used according to identify the perspectives and ideas about the layout of the farm. It can be assumed that not all stakeholders are able to read and write. Since smallholder farmers are one of the most influential stakeholders it is necessary to adapt the methods to make it possible for everybody to contribute to the mapping in the same extent. Additionally, social and socio-cultural issues are tackled with this method. In a verbal conversation, socially less acknowledged groups or persons might not speak or mention all important topics in presence of 'higher' persons. The mapping gives the chance to everybody to contribute in the same way and not to take care about the social environment that might influence that very same contribution. Participatory mapping has developed as the most widespread participatory methods of all (Chambers, Participatory Mapping and Geogrphic Information Systems: Whose Map? Who is empowered and who is disempowered? Who gains adn who loses?, 2006). According to IFAD participatory mapping can contribute to six different purposes (IFAD, 2009):

- To help communities articulate and communicate spatial knowledge to external agencies
- To allow communities to record and archive local knowledge

- To assist communities in the land-use planning and resource management
- To enable communities to advocate for change
- To increase the capacity within communities
- To address resource-related conflict

Primarily there are four of the named purposes that support the aim of this participatory method directly. The others might be side-effects to that project but still are of importance concerning internal community processes.

5.2.6.5 Participatory Diagramming

Additionally, *participatory diagramming* to collect the different ideas about cultivation practices and rhythms is intended to support information gathering. The diagramming approach can be easily done with local materials integrating words or completely without written words. A precondition is the understanding of every single part of the diagram by every participant. To ensure post-exercise action among the certain stakeholder group, to ensure the possibility of triangulation of the information and to simplify the convenience of the organization diagramming should be conducted among people who know each other (Kong, 1998). The participants need to be clustered in peer groups to ensure the triangulation within one stakeholder group (e.g. women and men as single peer groups in the stakeholder group of *smallholder farmers*). This can be structured in more detail after the stakeholder analysis (Kesby, 2000).

The main outcomes of this methods are anticipated with a seasonal calendar and a detailed overview about the water demands of these agricultural systems (Wiliams, 2014). The seasonal calendar is aimed to show a certain cultivation pattern that is according to the local practices and periods of rainfall. The water demand can be expressed by a diagram concerning the water demands of the cultivated crops and additionally the usual rainfall periods. This information might carry a high risk of uncertainty because the precipitation might not occur in a dry year when it does in a year with higher precipitation rates. For these cases there need to be measures taken into account to buffer these insecurities in the realization phase of the project.

5.2.7 The Program

The different participatory approaches are used after the initial stakeholder-wise interactions to bring the different perspectives together and compose a first draft of the model (for the prototype) including all perspectives. According to the conceptual framework and its different stages for the methodology the consequences are the following. In phase one the different stakeholders are analyzed. Additionally, in this phase the methods are used to identify the different interest and information stakeholder-wise. In phase two interviews and simple field observation will add to the created picture within the participatory workshops. After the evaluation of those in combination with the evaluation of the participation outcomes a fusion of all the ideas, perspectives and associations concerning the model will be presented to the stakeholders. At this occasion, the fields of tensions and the similarities need to be pointed out to enable a communication between the different stakeholders. Having brought up the critical issues a negotiation about these topics is enabled. Out of this negotiation and participation process it is possible to agree on a final draft for the prototype integrating the different stakeholder perspectives.

5.2.8 Organic Advisory Group (OAG)

The modelling of the farm as explained in the introduction chapter of participation is favored to happen in a participatory exchange of knowledge. Therefore, the aim has been to create an *Organic Advisory Group* that deals with the topic of organic farming concerning the planning of this farm. This group is meant to support the planning of the model farm from scratch. This entails all sorts of subjects and expertise. The group needs to cover the expertise of soil and water science as well as plant and social science. The integration of more disciplines in the planning, implementation and evaluation sustain the long-term establishment of the farm. No matter the fact that the complexity of the farm increases additionally the resilience of the farm increases. As well as the innovative character enlarges the local possibilities. If more disciplines come together and exchange opinions and knowledge the resulting consequences are seen as innovative mergers of transdisciplinary exchange.

To include as many disciplines as possible and up to a certain and reasonable extent the complexity rises. The first members of the group have been selected by a male researcher of BDU in cooperation with a professor of organic farming from the Austrian partner university BOKU. There were four of them who are the natural science and already introduced in organic farming. They as young researchers of BDU were engage to integrate more students from BDU from different disciplines and additionally from different gender, since all selected so far are male. The three initial members of the *OAG* encouraged two more members for the group – both male and from natural science – from the department of fishery and a research assistant from ARARI in the water management. Through this the horizon of the group has been enlarged and then was able to cover all agricultural and nature-linked topics. Still missing was a gender balance as well as other disciplines that would point out the social and innovative character of the model farm.

The *OAG* was supposed to support the two main researchers that are responsible for the implementation of the model farm. Regular meetings happening twice per months should give an indication and feedback for the researchers how the model farm development progresses. These regular meetings have been introduced since the formation of the *OAG.* The Terms of Reference for the group integrate an obliged continuity of presence of all members.

5.2.8.1 Initial Steps

In the first steps it is described how the framework with certain ToRs has been set up to engage the power in decision making and advisory of the participants and to support their feeling of being an active member of the group. It also will be explained how the group has been formed, that there have been several participants that misunderstood or had the wrong perception in first instance and dropped out of the group again.

Concerning the participation in planning, implementation and evaluation of projects the common mindset needs to be stated. Therefore, it is important that in the first meetings every participant states his motivation behind the contribution to a certain project. This helps the project owners, the facilitators and the other members to understand the driving forces of each one of the participants. With this transparency, the facilitator is clearer about the motivation about the participants. In cases of voluntary participation these can vary from a huge range. One can be motivated by the opportunities that develop out of such a project, including the network that is build up, the contacts. And others might be in hope of job opportunities. Others are in hope of monetary support, since the paradigm still is present – when somebody from the North starts a project somewhere there will be finances for it. In this case, it had to be made clear that the project has no external funding beside the university of Bahir Dar. This led to the disappearance of a member of the *OAG*. This particular member was motivated to create a link to two potential farmers joining the project. Apparently, the lack of financial resources supporting the project has been an argument to leave the *OAG*. Here the patterns of development cooperation and international project between “South and North” get into the spotlight and show the establishment that has been taken place over the decades. Patterns, that show the perception of projects linking the knowledge of different research institutions, of monetary support and subvention from foreign institutions.

The Terms of Reference have therefore been established and ensure the understanding of this participating group. There are two interesting facts for the understanding of the creation of this contract. The participants have voted for such a contract. This has to do with the acknowledgment that they earn through this. Additionally, and even more important for the functionality of the project is the professionality of the participants. They themselves perceive the OAG only as ready to act when there is a clear institutionalization of the group. The group perceived as institution form external might have more power concerning decision making and advisory than perceived as an accumulation of different individuals. In the Ethiopian context this adaption of the framework of a group is reasonable since the OAG is aiming to act as a main consultancy for the planners of the model farm. Additionally, since the participants are members of this group voluntarily can be rewarded through this acknowledgement through the participation e.g. like a membership of a planning, evaluation and planning process.

5.2.8.2 Role of the Facilitator and Researcher in the OAG

The facilitator in this research is the main research. In the group sessions the facilitator will engage in an exchange of knowledge with guiding through different questions and objectives. The facilitator in this study is the modeler of the modelling tool. This is an advantage in concerns of understanding the limitations and possibilities of the model. The gathered output of the workshops with the OAG can that way be directly inserted.

Additionally, the facilitator takes the responsibility of the organization of the workshops and its recognition at university level – according to the wish of the members of OAG. The facilitators is meant to create space for the participants to share and exchange knowledge and expertise about certain topics. With the participatory observation method the facilitator is able to switch later in the researchers role and reflect on the workshops. Additionally, the participants are engaged to intervene any time in the workshops if the facilitation goes in a not wishful direction. This and a round of feedback at the end of each workshop ensure the workshops facilitation is concurrent with the participants' expectations.

Since there is also a gender workshop planned the facilitation might need adaptation. The facilitator in a gender discourse in the Ethiopian context can lead to difficulties. Therefore, the gender workshop is handled more lose and the facilitator only is aimed to open and close the session and intervene when requested by the participants. This open setting will be lead through one question about potential innovations in the different sectors – HH, Agriculture and Economics & Market.

Nevertheless, the combination of the facilitator and researcher in one person has advantages but carries also challenges as earlier mentioned in the chapter *The facilitator.* Therefore, a conscious facilitation of the workshop and a high level of situational reflectivity are requested.

5.2.9 Gender

Human development in Africa is rising and low human development countries are catching up, despite persisting inequality within countries and between women and men. (UNDP, 2016)

In this research, the challenge is to create space and progress for the ones that are individuals being studied (Cooke, 2001; Cornwall, 2003; Kesby, 2000; Maguire, 1987; R. F. Pain, P., 2003). To overcome and offer an option in the gender debate and to show a model that integrates aspects and possible shifts in the socio-cultural context, the necessity of a gender perspective is a logical conclusion. This conclusion is drawn out of decades of development work in which the role of the women at last got the same recognition than men. Even more the role of women concerning certain topics is of higher value than the perception of men. These topics include HH based and sanitation based processes where women are mainly involved. But in other fields like agricultural business women are increasingly supported in their independences and leadership of the business (UNDP, 2016). The fact the 61% of women are contributing to the labor forces (excluding subsistence) in northern Africa – which Ethiopia is part of – logically let women be considered as full member of a developing society and country (UNDP, 2016).

Wiliams et al. point out that the "uncertainty regarding whether gender roles needed to change to break the cycle of poverty or whether the maintenance of the *status quo* would prevent a sense of loss" (Wiliams, 2014). Meant is the feeling of a loss in the wider sense of the whole gender consideration. If potentially gender changes patterns of poverty the Wiliams et al. doubts if this might engage the feeling that there had been missing something. This quote raises the question of a gender perspective in development processes.

In this project a group of female academics will be integrated in the planning, implementation and evaluation process of a 10 ha model farm run by the Bahir Dar University. This integration engages the inclusion of a gender perspective concerning HH based, agricultural and agro-economic issues. For the planning, implementation and evaluation it is important that in the following these three phases will be called the process, the process of the model farm.

Questions remaining and unpredictable start with basic things like the effect of any awareness creation. And even before, it needs to be asked: Why gender considerations need to be integrated within this project? And if there is a clear goal for this, who and how should the important parties be included? How will a community react that has been previously concerned with gender issues? Who needs to be included? Under which circumstances can a gender-integration process be successful? How can we evaluate the success of integrating gender values? Where does the process face obstacles and what would be needed to cope with these obstacles concerning gender related topics? …

In the following, the major challenges of gender in general are summed up and the questions above are tried to be answered for the specific case of this research.

5.2.9.1 Participation & Gender (an inclusion or an add on)

The planning process of an innovative model farm in organic farming evidently includes the challenging of social inequities – in this chapter and case, the inequity between the perception of women and men. The integration of different perspectives in the process concludes in a tensional and partly contradictory participation process when introducing gender issues in an African country (Cornwall, 2003).

5.2.9.2 The Integration of a Gender Perspective but how?

The practical realization and tackling of gender related issues had been successful in cases where the women organizations have been institutionalized and promoted the contribution of women. Women gathered confidence in those infrastructures and formed alliances for the representation of their interests (Cornwall, 2003).

Institutions can enable women to challenge their exclusion. (Cornwall, 2003)

For a proper implementation of any project in a particular system the same system should be understood completely. That way, it appears to be easier influence that system. Women visibility and women voice in political context are criteria having a certain impact in order to affect social change (Wiliams, 2014). The studies of Wiliams et al. (2014) advocate to achieve women visibility in political context through education and training. Lots of research articulated education and training as one major threat to gender inequality (Kome, 1997; Maguire, 1987; Meinzen-Dick, 1998; R. Pain, 2004; Robert Chambers, 1991; Scoones, 1998; Wiliams, 2014). More interesting is the way how to achieve these goals and what is meant by this in the particular cases. In the case that had been described by Wiliams et al. (2014) the integration of the local youth – gender balanced – had been a major advantage since they first had the chance to have impact on their own future. As mentioned earlier, the integration of the youth in the planning, implementation and evaluation showed that the participation of the youth results in the willingness to action. In this context there is no reason to separate or make any difference of men and women since the focus is not on gender but on another goal that counts for all. This action and the implied change are mainly driven by the community development by tackling the subjects of skill development, the increase of knowledge, power and capacity which were earlier named as part of the justification for gender inequality (Wiliams, 2014).

A major constraint for facilitators in a participatory process is to create situations where women feel comfortable and confident enough to be able to share openly their thoughts, experiences and doubts. The choice of the right setting starts with thinking about public/gender-mixed meetings or closed/woman-only meetings. This differs from situation to situation and needs flexibility and adaptability (Cornwall, 2003). To create a 'safe space' like mentioned by Meinzen-Dick et al. majorly contributes to an open exchange between the stakeholders (Meinzen-Dick, 1998).). Indeed, it can be helpful to separate certain stakeholders from others to exclude the invisible hierarchical, social or cultural order that exist between them. Each one of these orders can act as oppressions that prevent certain stakeholder to fully express themselves in presence of another stakeholder – in many cases women in presence of men–(Kome, 1997). The idea would be to integrate the women-only/gender-separated groups then again in one big 'action plan' (Cornwall, 2003).

Regarding a proper implementation of organizational structures or processes taking into account gender issues, it is necessary to be aware of the impossibility to generalize women's interests. The need of a situational adaptation triggers the question what is actual possible in a process like this. For example, it might be necessary to develop different action plans in with different stakeholder or involved groups. A general plan is not fitting to the different situation that can occur in one and the same project. Meinzen et al. answers with the identification and the analysis of how gender shapes and influences the interest, possibilities and perception (Meinzen-Dick, 1998). The generated awareness of these outcomes is the chance to make a difference through the inclusion of gender in the participatory projects. A participatory process is not meant to change purposely the cultural gender inequality, but raising the awareness in a planning and implementation process gives the chance to the participants to get active themselves.

5.2.9.3 Gender & this Research

This study consists of the planning process for the implementation of an organic farm in Bahir Dar (Ethiopia). The importance to include a gender perspective within the planning has been previously discussed in this chapter, as well as the necessity for a women group to be able to gather for empowerment and make their voice socially louder (Cooke, 2001). Since the researchers are male the introduction of a women group has been obligatory to exactly tackle the previsouly mentioned challenges and advantages. Due to the fact that the planning process has been steered out of a scientific perspective it is important to also include that same level of knowledge and reflectivity in the planning process. So a high educated women group is the most suited to face the male dominated scientific *Organic Advisory Group*. That way, the women group can debate on the same level as the advisory group and there is no educational gap that could lead to misunderstandings. For this matter, seven young women have been selected to integrate and gain a deeper perspective on the different topics agriculture is facing concerning gender issues. The group consists of seven women between 25 and 45 years old. All women have educational background situated at the Bahir Dar University (BDU). Their range of expertise is from development studies, social science, anthropology to geography. Three of the women are PhD candidates analyzing the social role of women in agriculture.

The gender group has been formed to find the innovation gaps in agricultural practices concerning the role and perception of women. The aim of this group is to gain awareness and knowledge exchange about local HH, farm and economic practices and within these the role of the women. The focus of this group is to look beyond the obstacles and hurdles found in socio-cultural settings and to identify key innovations that are able to change the position and role of the women into a role women are willing to be identified with. This is another topic the gender group is tackling.

The leading questions of the group are:

- What are certain determining hurdles for women in agriculture – socially, technically, politically?
- How and where can innovations help to overcome certain determining hurdles?
- What are the innovations on political, technical and social level?
- How can the pathways be influenced by the integrated planning of the model farm?

Since five of the seven researchers that participate have an agricultural background they are able to describe and point out certain developments in the last decades. Together with their educational background they are now able to reflect in certain topics better than the actual farmers. To see the drawback an outer perspective that is still part of the system helps to reflect certain situational constellations more in detail (Robert Chambers, 1991).

The setting for the group is selected by the facilitators that invited the women to join. Through key informants the participants could be selected. Together with the group it is decided to have workshops concerning the planning process of the farm. The first workshop is meant to trigger the major challenges of women in agricultural surrounding from on the whole range of social, political and technical issues. The group creates awareness for the important topics that have to be integrated in a planning process and that might be neglected from a researchers' perspective.

Picture 1: Gender group workshop

Therefore, the question about which innovation can help to tackle certain disadvantages for women in agriculture are divided in perspective of Household level, Agricultural level and Economic & Market level. These levels have been developed in the workshop with the group. They give indication about all important topics and cover according to the group almost all issues they are of importance. In the first workshop the general topics have been pointed out.

6 RESULTS

6.1 Model Creation

The chapter model creation guides through the process of the first stage of the model development. It entails the principles the model is based on and contributions of different disciplines through the interviewees – see *Introduction.* Continuing with the description of the different farm subsystems an overview of the different agricultural practices and products will be given. This entails explanations about the crops cultivated, nutrition balances, agroforestry and animals kept. Additionally, the technical infrastructure that is constructed and used on farm will be analyzed including calculations of the water requirements for irrigation implementation and water harvesting structures. Constructions like houses and buildings for other purposes are also modeled. The calculations of the planted crops and produced animal products that determine the economic situation of the farm are simulated in the chapter economics. These simulations are brought together in the total gross margin calculation for an overview of the performance of the farm modeled.

6.1.1 Introduction

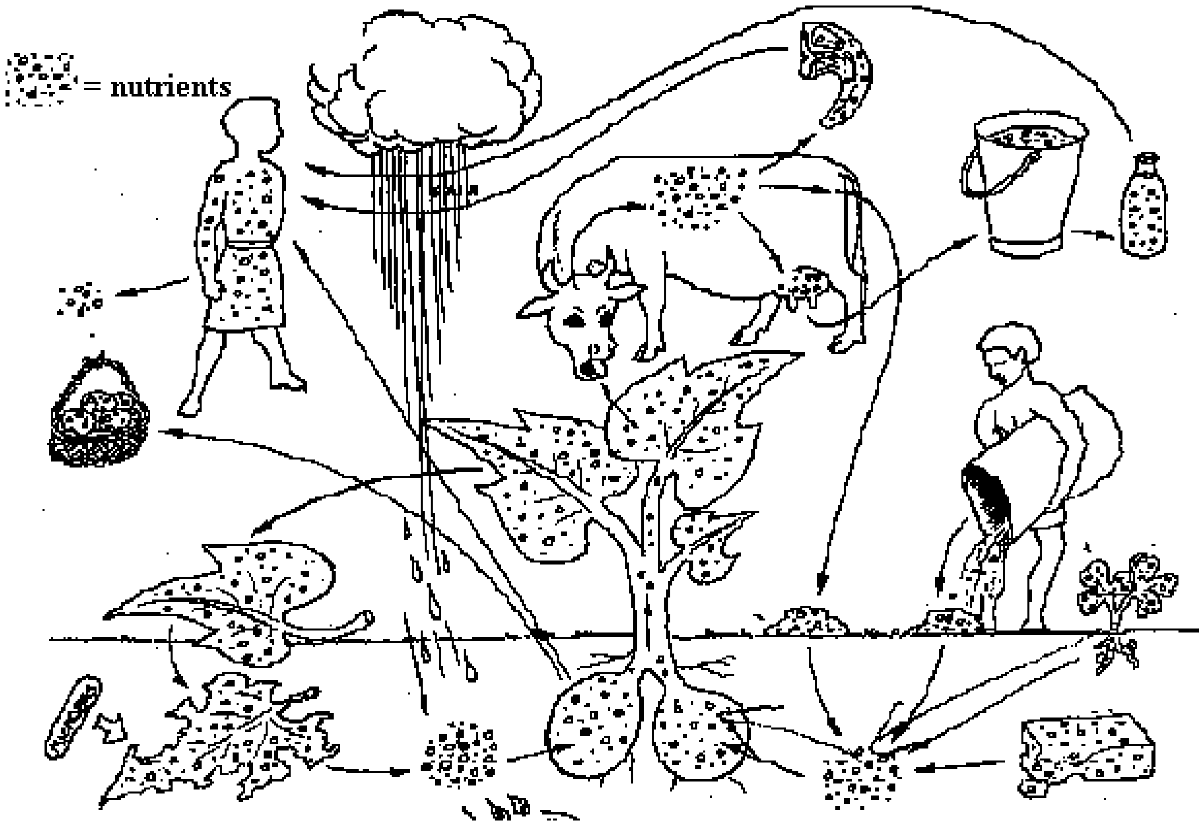
In the following the creation of the model is described excluding the details about the different interviews and workshops done. The interviews have been carried out in an informal setting with different stakeholders and experts. The main experts (interviewees) involved for the model creation were:

- **Prof. Bernhard Freyer (BOKU):** Input for Organic Farming from a systems perspective. Interrelations between different inter-agricultural and economic principles.
- **MSc Doris Wendt (SMIS):** Input for Water and Irrigation.
- **Dr Gabriele Gollner (BOKU):** Input for Nutrient, Fodder and Stable Balances. Specifications in tropical conditions.
- **Organic Advisory Group (BDU):** Local input on economic and agricultural knowledge.
- **Dr. Yuji Marou (ESS):** Input on ground water and geology information.
- PhD Menale Wondie Mulu (BDU): Input on agroforestry system

The model aims to illustrate all input and outputs of natural resources, labor and monetary investment, spending and income in a smallholder farm concerning agricultural production. Therefore, the need to integrate all sorts of expertise in the model is a logical conclusion. The model is developed and used as an example to transfer the expertise and knowledge to the participants applying and working with the model. The model works with a setup that is mainly meant for organic farming but can be adapted to other sorts of agricultural practices. In the chapter *Farm subsystems* this will be described in detail. The underlying principle of the setup is originated in the system thinking approach of perceiving a farm as a system with different interacting and related elements and subsystems that influence each other continuously.

The description of the single parts of the model is based on different interviewees. Concerning the different expertise, the different interviewees have brought inputs in their professional fields. In the following chapters the contribution is indicated according to the topics. With using the model as a tool in agricultural planning the users aim to gather knowledge about the different interactions and relations in organic farming.

In general, the model is based on the IFOAM principles, norms and standards (IFOAM, 1998) of organic farming.



Picture 2: Soil nutrient cycle (Source: http://www.uq.edu.au/_School_Science_Lessons/Soils2.html Access: 09.05.2017)

The model entails the cropping patterns (alley farming), the selected crops, closed nutrient cycles and is based on the system thinking. Within this the farm is understood as a system that is made of elements which create a system though their interlinkages and relations. A simulation delivers calculations about e.g. nutrition balances or economic outcomes that are helping in a consultation and research process. Through this it can be modelled in how far this modelled farm is comparable to the actual agricultural practices and how beneficial the model farm is.

The data inputs that are used for calculations in the model are outcomes of the workshops with the different groups and experts and diverse literature sources.

In the following the different chapters are guiding through the functionality and the structure of the model. The detailed model description starts with a user interface where the required data for a proper modelling can be entered. Based on those inputs the model demonstrates how the farm would look like in Figure 5. Five main chapters are following to analyze specific factors for the farm – *Arable land, Animal Husbandry, Water in agriculture & HH.*

The model is based on the organic farming standards. Nevertheless, all kinds of farming can be simulated – conventional, integrated, organic with this model. Additionally, the conditions for the model creation were found in this case are dominating the development – 10 ha of farmland in a sub-tropical climate. The following chapters will describe one potential simulation about a model farm based in Bahir Dar with sub-tropical weather conditions.

The farm in this model is meant to simulate under perfect conditions – unlimited financial resources, no water scarcity (in the plant growth simulation and irrigation calculations), stable climatic patterns (no extreme events), unlimited labor forces (meaning that there is no work that cannot be done due to work force) – all sorts of natural and economic flows. It is assumed that a ten-hectare farm is divided into eight to ten plots that are fenced by trees and shrubs creating so called alleys (I.e. alley farming) rows. Another underlying principle is the integration of the infrastructure on the farm into the whole system since this is a major point of in- and outflows. As displayed in Figure 5 different subsystems are integrated in the farm and have different contributions.

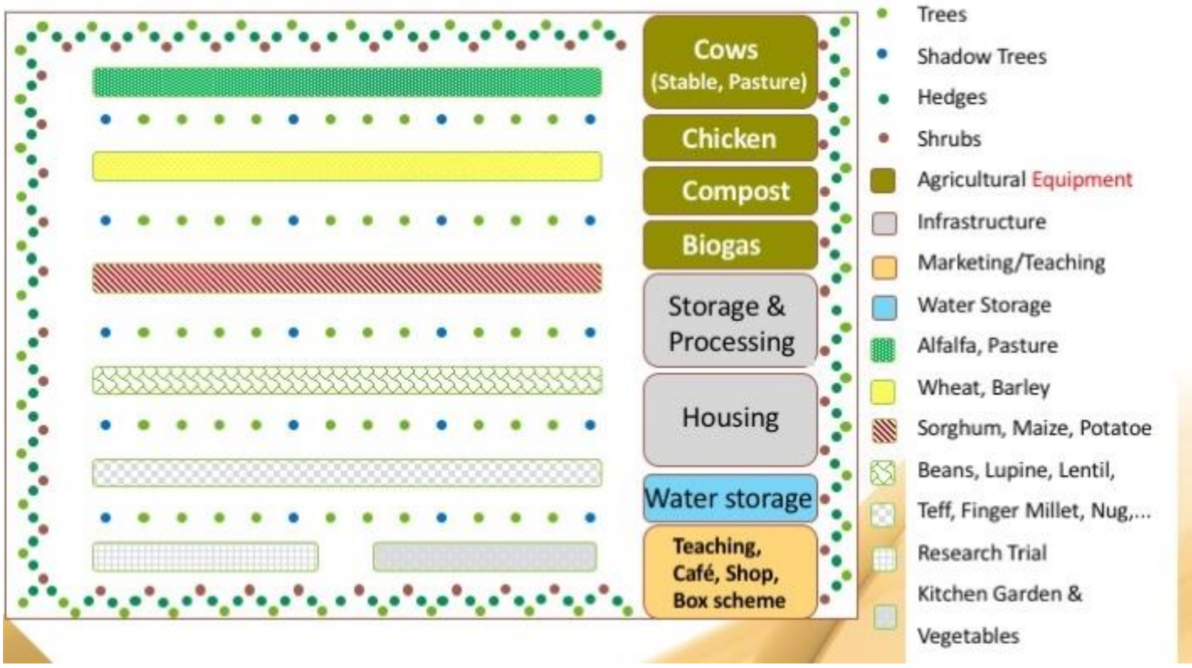


Figure 5: Extract of the farm presentation (the outline of the farm) – Definition of the farming system with its subsystems

For the actual model with all calculations and algorithms the software Excel has been applied since it was estimated to be fulfilling for the purpose of drafting this particular case and the first stage of the modelling process. In the context of the MSc-Thesis of the author the task has been to create a first framework to model an organic farm in a participatory manner. This idea has been agreed on with Prof. Bernhard Freyer. The aim is to provide an overview of the different elements and interlinkages of an organic farm. In a later development stage of the model it will be necessary to change to a more advanced software that can process more information and gather the necessary information automatically.

If the model – as aimed – will be used for the teaching and learning of agricultural system thinking through all sorts of disciplines it needs functions to adapt easily to different circumstances and better fit alternating surroundings. Additionally, the usability of the modelling program needs easier accessibility to lower the technological hurdle users might face.

This model works with a user section – at this stage of the development an excel sheet – where details need to be filled in like the crop, the area, the infrastructure, the economic in- and outflows, the fence constellation (with hedges or trees) and animal production. All these single tables will be filled with certain information with site-specific data in advance or in the process – the master data. These data are meant to be adapted to each case that the model is used for. In every section following explaining a part of the model the user interface is indicated with a grey background. This gives a better indication

Overview Farm		**ha**	**%**	**Comments**
land width (m)	500	0,05		
land length (m)	200	0,02		
land overall (m2)	100000	10	100,00	width*length
alley tree (width) (m)	1	0,0001	0,00	width of the single tree in an alley
alley width (m)	10,00	0,001	0,01	width of a single alley + arable area in between

single tree (m2)	2	0,0002	0,00	m2 per tree
Single hedge (m2)	1	0,0001	0,00	m2 per hedge

Outline		ha	%*	***percentage of total farm area**
Circumference farm land (m)	5600			
Length of border (m)	1400			surrounding border of the whole area
Natural fence area (m2)	5600	0,56	5,60	
Planted trees (4m distance)	350			amount of trees planted with the distance of 4 m
hedges (2m distance)	700			amount of hedges planted with the distance of 2 m

Infrastructure	**m2**	**%***	
Total area of infrastructure	2424	2,42	*percentage of total farm area
Infrastructure width	492		
Infrastructure length	5		
Housing	100	0,10	
Water storage	400	0,40	
Cows stable	300	0,30	The infrastructure is calculated as an area that is along the length of the whole compound. This is exemplary and does not match with reality. The model is in the current state of functions not able to calculate differently.
Chicken	100	0,10	
Teaching area, Sanitary, Shop	200	0,20	
Storage, Processing	400	0,40	
Compost	100	0,10	
Biogas	16	0,02	
Free space area	808	0,81	

Arable land		ha	%*	*percentage of total farm area
Total arable area (m2)	91976,00	9,20	91,98	
Arable land (without research) (m2)	81976,00	8,20	81,98	
Alley length (m)	187,07			alley length calculated with total length – the infrastructure length
Width of all alleys (m)	491,7			total width of all alley added up
Single alley width with tree (m)	11,00			single width of an alley
Amount of alleys (number)	40			
Area of single alley (m2)	2057,80	0,21	2,06	
Agroforestry** within rows (excluding natural fence) (m2)	7452,36	0,75	7,45	**for further detail of agroforestry see chapter Animal Husbandry
Arable area of alleys (m2)	74523,64	7,45	74,52	
Vegetable Plot*** (m2)	5000,00	0,50	5,00	***mainly for HH consumption; not taken into the economic calculations
Research trial (m2)	5000	0,50	5,00	

about the information that is required in the modelling process.

After the insertion the model calculates the following numbers automatized:

- distribution of the different cultivation areas,
- crop-rotation over a cycle of 8 years

- the seeds needed for sowing,
- the yield (t/ha and € or Birr),
- the nutrient balances (farmgate & stable),
- the animal products,
- water requirements,
- the investment and return.

6.1.2 Farm subsystems

In this chapter the general data of the farm are calculated including the information about how the farm land is divided into plots. There are several factors that come into play, including the arable land, overall infrastructure, the fencing system and specifications about the cropping rows. The infrastructure is assumed to be gathered in a specific dedicated part of the area for simplifying transport and installation.

The different types of landuse as displayed in **Error! Reference source not found.** are divided in arable land, infrastructure and agroforestry. Concerning the matter of agroforestry, it needs to be stated that the agroforestry system is reduced to the natural fence and the rows between the alleys. In the following these different landuse types will be explained as far as for this case of interest.

Table 3: Land distribution specifications (grey: to be filled by user)

In the following only a short overview is given about the different usages of the land and the farm activities and why they are integrated in the model.

6.1.2.1 Arable land

The calculations for the arable land are based on the difference between the total available and the hedges and infrastructure. The share of this area is increasing with the total area since the infrastructure is alternating minimally.

The arable land is again divided in research plots and rows. The research plots are meant for this special case and to integrate in daily farming business the trials of e.g. other crops or different cultivation practices. Additionally, the arable land is not only used for crops but also for partly forestry. The rows that separate the fields – as explained in the chapter *Model Creation* – are divided by trees and hedges. Different tree categories are chosen to widen the variation of produces. The main tree types are timber trees, fruit trees and tree Lucerne.

Table 4: Arable land – with different predefined purposes (e.g. agroforestry that is meant to take place in one particular area)

		ha	**%***	***percentage of total farm area**
Total arable area (m2)	**91976,00**	**9,20**	**91,98**	
Arable land (without research) (m2)	81976,00	8,20	81,98	
Alley length (m)	187,07			alley length calculated with total length – the infrastructure length
Width of all alleys (m)	491,7			total width of all alley add up
Single alley width with tree (m)	11,00			single width of an alley
Amount of alleys (number)	40			
Area of single alley (m2)	2057,80	0,21	2,06	

Agroforestry** within rows (excluding natural fence) (m2)	7452,36	0,75	7,45	**for further detail of agroforestry see chapter Animal Husbandry
Arable area of alleys (m2)	74523,64	7,45	74,52	
Vegetable Plot*** (m2)	5000,00	0,50	5,00	***mainly for HH consumption; not taken into the economic calculations
Research trial (m2)	5000	0,50	5,00	

6.1.2.1.1 Crops & Yields

In this section the specifications for the crops are summarized. To tackle the problem of yield variation according to different growing conditions low yields and high yields are indicated. In a later stage it is aimed for the user to select between different crop performances. Several factors are influencing the crop performance. Therefore, it is important to be able to estimate the influence of critical growing conditions indicated in low yields. These estimations are based on the interview with Prof. Bernhard Freyer including the crop selection for an optimal crop rotation according to the organic farming principles.

Table 5: Crops & yield (t DM/ha)

Alfalfa		**Wheat**		**Barley**		**Sorghum**		**Maize**		**Nug**		**Lentiles**	
min	2	min	3	min	0,2	min	3	min	4	min	0,7	min	0,4
max	10	max	4	max	0,8	max	5	max	6	max	0,9	max	0,5
avg	6	avg	3,5	avg	0,5	avg	4	avg	5	avg	0,8	avg	0,45

Potatoes		**Teff**		**Beans**		**Lupine**		**Vicia hirsuta**		**Faba beans**		**Chickpea**	
min	8	min	2	min	0,3	min	1,5	min	1,5	min	1,5	min	1
max	12	max	N/A	max	2	max	3	max	2	max	2,5	max	1,8
avg	10	avg	2	avg	1,15	avg	2,25	avg	1,75	avg	2	avg	1,4

Legend: grey to be filled by user; min: minimum yield expectation; max: maximum yield expectation; avg: average yield expectation

6.1.2.1.2 Crop Rotation

In this section the crop rotation that has been filled in the first spread sheet with the specifications of yield and sowing date is analyzed in detail. The simulation allows to enter all kind of crop rotations, conventional, integrated as well as organic ones. For this simulation the crop rotation has been constructed in cooperation with the expert for organic farming Prof. Bernhard Freyer. The crop rotation has been adapted to the organic principles.

Table 6: Example Crop rotation schedule for year x

YEAR				INPUT		OUTPUT
Plot Number	Crop	JUN	NOV	seeds kg/ha	% Seeds bought	Sold
1	Alfalfa		X	10	0%	0%
	Alfalfa			0	0%	0%
2	Alfalfa			0	0%	0%
	Alfalfa			0	0%	0%

3	Maize		X	27,5	0%	100%
	Faba beans	X		150	10%	90%
4	Potatoes		X	2000	10%	90%
	Teff	X		9	10%	100%
5	Lupine		X	75	10%	0%
	Nug	X		12	10%	100%
6	Wheat		X	125	10%	100%
	Chickpea	X		100	10%	100%
7	Teff		X	10	10%	100%
	Sorghum	X		12	10%	100%
8	Beans		X	150	10%	100%
	Nug	X		12	10%	100%

Grey: to be filled by user
Columns JUN and NOV indicate planting season with X this is to be adapted to every new simulation case

On the field this implies a certain knowledge of the farmer or/and extension worker about crop rotations and growing seasons. In case that there is insufficient knowledge this tool can be used to teach and develop knowledge before applying it. The models' calculations and linkages can explain the relations between different topics in the field. That way users are able to understand natural principles and functions by using the model.

There is a continuous alternation within a plot between N-fixation-plants and cash crops for nutrition or sales. Through this the plots generate a positive N-balance protecting the soil concerning overexploitation. Additionally, the rotation integrates a pattern that enlarges the water delivery to the crops. The crops for sales and subsistence are mainly cultivated in summer (according to this case) when the extended rainy season is ensuring higher precipitations. The higher probability of yield losses due to droughts is that way limited to a certain extent (Holden & Shiferaw, 2004). This cropping specifications need to be adapted to the differing local conditions the model is applied to.

Data for the amount of seed material are given by the participatory workshops with the OAG. The decision of the amounts per yield that are sold and used as fodder, mulch or HH-use are taken in consolidation with the organic farming expert.

In **Error! Reference source not found.** the whole crop rotation for one year on a whole farm is displayed. The main readings out of this table are the potential tons of different crops that can be sold or used on farm. Additionally, the estimations about the amounts of needed seed material give indication for the farmer about his expenses. This information will be used in the following calculations.

Table 7: Crop rotation

AREAS	Grain yield	JUNE (planted=1)	NOV (planted=1)	Amount of seeds kg/ha	Seeds bought	Corn-Yield t/ha	Field size (ha)	Seeds needed for cultivation (kg)		seeds cultivated	Yield (t)		Sold		Fodder/Mulch/HH-use	
								JUNE	NOV	%	JUNE	NOV	%	t	%	t
plot 1	Alfalfa	1	0	10	0	6	0,93	9,32	0,00	1	5,59	0,00	0	0	1	5,59
	Alfalfa	0	0	0	0	6	0,93	0,00	9,32	1	0,00	5,59	0	0	1	5,59
plot 2	Alfalfa	0	0	0	0	6	0,93	9,32	0,00	1	5,59	0,00	0	0	1	5,59
	Alfalfa	0	0	0	0	6	0,93	0,00	9,32	1	0,00	5,59	0	0	1	5,59
plot 3	Maize	1	0	27,5	0	5	0,93	25,62	0,00	1	4,66	0,00	1	4,66	0	0,00
	Faba beans	0	1	150	0,1	2	0,93	0,00	139,73	0,9	0,00	1,86	0,9	1,68	0,1	0,19
plot 4	Potatoes	1	0	2000	0,1	10	0,93	1863,09	0,00	0,9	9,32	0,00	0,9	8,38	0,1	0,93
	Teff	0	1	9	0,1	2	0,93	0,00	8,38	0,9	0,00	1,86	1	1,86	0	0,00
plot 5	Nug	1	0	75	0,1	0,8	0,93	69,87	0,00	0,9	0,75	0,00	0	0,00	1	0,75
	Lupine	0	1	12	0,1	2,25	0,93	0,00	11,18	0,9	0,00	2,10	1	2,10	0	0,00
plot 6	Wheat	1	0	125	0,1	3,5	0,93	116,44	0,00	0,9	3,26	0,00	1	3,26	0	0,00
	Chickpea	0	1	100	0,1	1,4	0,93	0,00	93,15	0,9	0,00	1,30	1	1,30	0	0,00
plot 7	Teff	1	0	10	0,1	2	0,93	9,32	0,00	0,9	1,86	0,00	1	1,86	0	0,00
	Sorghum	0	1	12	0,1	4	0,93	0,00	11,18	0,9	0,00	3,73	1	3,73	0	0,00
plot 8	Nug	1	0	75	0,1	0,8	0,93	69,87	0,00	0,9	0,75	0,00	1	0,75	0	0,00
	Beans	0	1	150	0,1	1,15	0,93	0,00	139,73	0,9	0,00	1,07	1	1,07	0	0,00
TOTAL (t or ha)				2,7855			14,9	2,17	0,42		31,77	23,10		30,65		24,22
TOTAL (kg)				2785,5				2172,83	421,99		31765,70	23102,33		30647,85		24220,18

6.1.2.1.3 Nutrient Balances

The nutrient balances of the model are meant to simulate the in- and outflows of the nutrients regarding the farm system, respectively the stable system. Concerning the nutrient balances a systemic understanding of the nutrient flows is important.

Basically, there are two types of balances. The farm-gate balance simulates the flows that are going of the farm through sales or percolation. Additionally, the inflows are fodder, fertilizers, seeds and the N-fixation capability of the legumes cultivates.

The second balance is the stable balance. This balance is simulating the nutrients in- and outflows of the stable taking the fodder as main input and animals products as output. Since the amount of the nutritional surplus in the stable defines the growth of the animals, it is important to simulate the nutrient flows. The simulation of the stable balance can give predictions about how the livestock is developing. According to these numbers it is possible to adjust the nutrition of the livestock and influence its growth. For the demonstration case it is calculated with cattle and chicken.

The nutrient balances – farm-gate & stable balance – are calculated and according to the examples that have been gathered with Dr. Gabriele Gollner (BOKU). Adaptations have been done concerning the climatic and crop conditions in coordination with Prof. Bernhard Freyer and the OAG. Additionally, certain nutrition values have been changed according to fit the local crop conditions and parameters – indicated in the figures.

6.1.2.1.3.1 Farm-gate balance

Important in the farm-gate balance is the definition which balance is chosen to be calculated. In the concerns of organic farming the only balance that is able to capture the organic farming system thinking is the farm-gate balance. This balance is meant to divide between nutrients that leave the farm and do not contribute to the farm-intern nutrient balance. The important point is to integrate also the stable production, as well as the estimations about dung and other animal products. The animals themselves in their different growing stages are a key parameter that is tended to be neglected. Therefore, it is obligatory to mention the presence or absence of animals in the user interface of the model.

In the first main table of the farm-gate balance – **Error! Reference source not found.** – the cropping pattern is displayed and the calculations for two growing seasons equivalent to one calendar year are done. These calculations are automatized by the model and integrate the information for the grain yield and the farmed area. **Error! Reference source not found.** and **Error! Reference source not found.** deliver an overview about the most important factors. The information about the animals is of major importance. It indicates the number of cows, their dung produced per year, their average weight, the milk produced per year and the percentage milk that is sold. Equivalent to this the conditions for the chicken are filled in the user interface.

Table 8: Animals

Cows	3		Chicken	40	
Dung per Cow	7500	kg/year	Manure/chicken	36,5	kg/year
Average weight cow	300	kg	Average weight chicken	3	kg
Milk production	3,5	t	Egg production/day	200,75	egg/year
% Milk sold	1	0	% Egg sold	1	0

To be considered in the stable composition

Table 9: Farm-gate balance – crop rotation

No.	Crop	Amount of seeds (kg/ha)	Grain-Yield (kg/ha)	Shoot/Straw Yield (kg/ha)	CP - crude protein grain (%)	Field size (ha)	Area farmgate balance (ha)	Sum (ha)
1	Alfalfa	10	6000			0,93	0,93	
2	Alfalfa	10	6000			0,93	0,93	
3	Alfalfa	10	6000			0,93	0,93	
4	Alfalfa	10	6000			0,93	0,93	
5	Maize	27,5	5000	6000	10	0,93	0,93	
6	Faba beans	150	2000			0,93	0,93	
7	Potatoes	2000	10000			0,93	0,93	
8	Teff	9	2000			0,93	0,93	
9	Nug	75	800			0,93	0,93	
10	Lupine	12	2250			0,93	0,93	
11	Wheat	125	3500	3500	11,3	0,93	0,93	
12	Chickpea	100	1400			0,93	0,93	
13	Teff	10	2000			0,93	0,93	
14	Sorghum	12	4000			0,93	0,93	
15	Nug	75	800			0,93	0,93	
16	Beans	150	1150			0,93	0,93	14,90

In the third table – **Error! Reference source not found.** – the calculations for the field inputs are done. The model takes the inserted data for the crops of the first spread sheet and links it to certain N-P-K-values that are backed-up in another table (for this particular simulation – the aim is to integrate certain data automatically in a further development stage of the model).

These N-P-K-values have been adapted in some cases to fit the local crop varieties and agro-ecological yield potential. Therefore, literature research has been done. The data enables an adaptation concerning the precision of the simulation. In the first block of the crops' nutrition, the values of the sown crops are added up. The second block of the input table is about the N-fixating properties of legumes. The cultivated legumes deliver certain amounts of N to the soil and contribute to the nutritional enrichment of the soil. The third block in the input table is including all animal related nutritional values. These are animals themselves but also their manure in all forms contributing to the nutritional input – liquid, solid, rotted, etc. In the end of this table the sum of all nutritional inputs is calculated to compare later with the values for the output.

Within these parameters, the crops values – N, P, K – marked with a "*" have been adapted due to missing information and research in the tropical and subtropical climatic environments. The values are reduced by 0,3 (30% equals 70% of total yield) accordingly to the information gathered by Prof. Bernhard Freyer to adapt to the poor tropical soil conditions in this case.

Table 10: Farm-gate balance – Input

Product	Amount	Area/Unit	Basic data nut. contents N	P	K	Total nutrient content N	P	K
	kg/ha or m³	ha	kg/100kg (dt) or m³			total kg		
Alfalfa	10	0,93	5,50	0,64	1,04	0,51	0,06	0,10
Alfalfa	10	0,93	5,50	0,64	1,04	0,51	0,06	0,10
Alfalfa	10	0,93	5,50	0,64	1,04	0,51	0,06	0,10

Alfalfa	10	0,93	5,50	0,64	1,04	0,51	0,06	0,10
Maize	27,5	0,93	1,50	0,35	0,42	0,38	0,09	0,11
Faba beans	150	0,93	3,70	0,45	0,90	5,17	0,63	1,26
Potatoes	2000	0,93	0,35	0,06	0,50	6,52	1,12	9,32
Teff	9	0,93				0,00	0,00	0,00
Nug	75	0,93				0,00	0,00	0,00
Lupine	12	0,93	5,40	0,55	1,10	0,60	0,06	0,12
Wheat	125	0,93	1,70	0,35	0,40	1,98	0,41	0,47
Chickpea	100	0,93	3,60	0,48	1,16	3,35	0,45	1,08
Teff	10	0,93				0,00	0,00	0,00
Sorghum	12	0,93	1,50	0,35	0,40	0,17	0,04	0,04
Nug	75	0,93				0,00	0,00	0,00
Beans	150	0,93	3,60	0,48	1,16	5,03	0,67	1,62
Cattle	900	1,00	2,45	0,60	0,20	22,05	5,40	1,80
Chicken	120	1,00	3,43	0,48	0,13	4,12	0,58	0,16
Liquid manure (cattle)	6387,5	3,00	0,50	0,07	0,00	95,81	13,41	0,00
Total						**147,24**	**23,09**	**16,36**
Total adapted to tropics		**70%**				**103,07**	**16,16**	**11,45**
/ ha	**Area (ha)**	**14,90**				**6,92**	**1,08**	**0,77**

The last table – **Error! Reference source not found.** – measures the outputs that are leaving through the gate of the farm. These values are taking into account how much of the produced crops is sold and how much is used for the

on-farm usage. The first block in this table includes all sorts of cash crops that are sold on the market or meant for any other purpose outside the farm system. These values are including the late development stage/ripening of the crops. In that stage of the crop development the maximum number of nutrients is extracted from the soil. A lot of nutrients are taken up by the plant and are missing in the soil Additionally, in the second block of this table the animal products and animals are listed that are sold off-farm. Concluding, the farm-gate balance finalizes with a balance calculation to check on the overall nutrition balance. All nutrient in- and output are taken together in a balance to give indication about how the crop rotation is expected to work. If the balance is negative in the end it is necessary to adjust the crop rotation and balance the deficits.

Table 11: Outputs and total balance (without N-fixation)

			Basic data nut.contents			Total nutrient content		
	Amount sold	**Area**	**N**	**P**	**K**	**N**	**P**	**K**
Product	**kg/ha**	**ha**	**kg/100kg (dt) bzw. m³**			**total kg**		
Alfalfa	0,00	0,93	5,5	0,64	1,04	0,0	0,0	0,0
Alfalfa	0,00	0,93	5,5	0,64	1,04	0,0	0,0	0,0
Alfalfa	0,00	0,93	5,5	0,64	1,04	0,0	0,0	0,0
Alfalfa	0,00	0,93	5,5	0,64	1,04	0,0	0,0	0,0
Maize	4657,73	0,93	1,5	0,35	0,42	65,1	24,5	6,8
Faba beans	1676,78	0,93	3,7	0,45	0,9	57,8	27,9	6,8
Potatoes	8383,91	0,93	0,35	0,06	0,5	27,3	1,8	2,5
Teff	1863,09	0,93	0	0	0	0,0	0,0	0,0

Nug	0,00	0,93	0	0	0	0,0	0,0	0,0
Lupine	2095,98	0,93	5,4	0,55	1,1	105,4	62,3	12,7
Wheat	3260,41	0,93	1,7	0,35	0,4	51,6	19,4	4,6
Chickpea	1304,16	0,93	3,6	0,48	1,16	43,7	22,5	7,3
Teff	1863,09	0,93	0	0	0	0,0	0,0	0,0
Sorghum	3726,18	0,93	1,5	0,35	0,4	52,1	19,6	5,2
Nug	745,24	0,93	0	0	0	0,0	0,0	0,0
Beans	1071,28	0,93	3,6	0,48	1,16	35,9	18,5	6,0
Milk sold	3675	1	0,56	0,09	0,14	20,6	3,3	5,1
Calves sold	200	0,8	2,45	0,6	0,2	3,9	1,0	0,3
Eggs sold	200,75	1	1,9	0,18	0,12	3,8	0,4	0,2
Chicken sold	3	20	3,43	0,48	0,13	2,1	0,3	0,1
Total						469,4	201,3	57,6
Total adapted to tropics		70%				328,57	140,92	40,34
/ ha	Area (ha)	14,90				22,04	9,45	2,71
Saldo (Input-Output)						-225,50	-124,75	-28,89
/ ha and year						-15,13	-8,37	-1,94

Due to the functionality of the legumes to fix N in the soil the total farm-gate balance is influenced concerning the N-concentration. In **Error! Reference source not found.** the calculations of the nutrients are done taking into account the Nitrogen fixation through the legumes.

Table 12: Total balance with N-fixation of legumes

With N-Fixation

			Basic data nut. contents			**Total nutrient contents**		
Crop	**Amount**	**Area**	**N**	**P**	**K**	**N**	**P**	**K**
	kg/ha	**ha**	**kg/100kg (dt) bzw. m³**			**Total kg**		
Alfalfa N fixation 1st (DM)	1000	3,726	3			111,8	0,0	0,0
Alfalfa N fixation 2nd year (DM)	1200	3,726	3			134,1	0,0	0,0
Faber Beans	2000	0,932	1			18,6	0,0	0,0
Lupine	2250	0,932	4			83,8	0,0	0,0
Chickpea	1400	0,932	4			52,2	0,0	0,0
Beans	1150	0,932	5,5			58,9	0,0	0,0
Total						**459,5**	**0,0**	**0,0**
Total adapted to tropics		**70%**				**321,64**	**0,00**	**0,00**
/ha	**Area**	**14,90472727**				**21,58**	**0,00**	**0,00**
Balance	**total**					**96,14**	**-124,75**	**-28,89**
	/ha					**6,45**	**-8,37**	**-1,94**

6.1.2.1.3.2 Stable Balances

The focus of the stable balances on the nutrients of a certain farm and potential nutritional deficits helps identifying certain nutrition gaps. With the simulation of the livestock units the calculations start and via analyzing the inputs through the crop rotation and analyzing the input and output balance.

In **Error! Reference source not found.** is calculated accordingly to the livestock at the farm. All living animals on the farm are considered. With a LSU, it is possible to talk about animals by leveling their value in a certain unit. This has the advantage that the numbers are easy to be compared. Different animals have different factors that influence the LSU, e.g. a cow has factor 1 and concerning the weight and size of an animal the factor decreases (see Annex). Additionally, in **Error! Reference source not found.** the animal specifications are given concerning the production of dung and milk, weight and eggs. Out of the first **Error! Reference source not found.** takes the information into account about the percentage of sold animal products. With the outflows of the stable the nutritional values can be calculated and simulated.

Table 13: Livestock Unit Calculations

Livestock Unit (LSU) Calculation			
Number	Type	Factor	LSU
3	cows	1,0	3,0
1	bull	1,0	1,0
40	chicken	0,0015	0,1
Total			4,1

Table 14: Animal Husbandry – Specifications

Cattle	
number	3
Dung per Cow (kg/y)	7500
liquid manure (l/day))	17,5
average weight cow (kg)	300
milk production (t/y)	3,5
% milk sold	100
Chicken	
Number	40
Manure (kg/y)	36,5
Average weight (kg/chicken)	3
Egg production / day	0,55
% egg sold	100

(excluding other animals for demonstration purposes)

Error! Reference source not found. contains the (field-)stable balance including feed staff, seed material, animals, organic manures and animal products. Only data that certainly is contributing to the stables increase or decrease is considered. The inputs are in this case the legumes and crop residues that are used to feed the cows and chicken. Additionally, straw is used for fodder (e.g. bean, wheat and maize). Like in the calculations of the farm-gate balance the total amount is reduced to 70% of the total nutrition since the master data have been from Mediterranean and European data bases – according Bernhard Freyer.

The output mainly contains the animal products respectively their nutritional values. Here in particular it is important to take all different animal products into the calculation. This includes sold animals (life or death), their products (e.g. milk, eggs) and living animals (e.g. calves). The different nutritional values have been defined in accordance to the information of Dr. Gabi Gollner (BOKU) and literature research (Kolbe). These LSU have been adapted in some cases to fit the tropical and subtropical circumstances from the original data – according to estimations of Bernhard Freyer.

Again, at the bottom of the table is a calculation of the nutritional balance of the stable. If there is a surplus in the stable it means a potential for growth of the animals. Only when the nutrition balance is positive there is potential to accumulate nutrients which is equivalent to growth.

Table 15: Stable Balance – Input

			Basic data nut. contents			Total nutrient content		
Product	**Amount**	**Area/Unit**	**N**	**P**	**K**	**N**	**P**	**K**
	kg/ha or m³	**ha**	**kg/100kg (dt) or m³**			**total kg**		
Alfalfa Hay	6000	3,73	2,54	0,26	2,53	567,9	58,1	565,6
Alfalfa (green fodder)	6000	3,73	3,86	0,47	3,75	863,0	105,1	838,4
Faba Beans	6000	0,93	3,70	0,45	0,90	206,8	25,2	50,3
Lupine	10000	0,93	4,00			372,6	0,0	0,0
Chickpea	3500	0,93	3,50	0,40	0,80	114,1	13,0	26,1
Beans	800	0,93	3,70	0,45	0,90	27,6	3,4	6,7
Cattle	900	1,00	2,45	0,60	0,20	22,1	5,4	1,8
Chicken	120	1,00	3,43	0,48	0,13	4,1	0,6	0,2
Total						2178,1	210,7	1489,1
Total adapted to tropics		70%				1743	169	1191
/ ha	**Area (ha)**	14,90				117	11	80

Total input to stable balance (also called: field-stable balance) including adjustment to tropical circumstances (estimated loss 20%)

Table 16: Field Stable Balance (Output & Saldo)

			basic data nut. contents			total nutrient content		
Product	**Amount**	**Area**	**N**	**P**	**K**	**N**	**P**	**K**
	kg/ha	**ha**	**kg/100kg (dt) bzw. m³**			**total kg**		
Fresh solid stable manure,	22500	1	0,183	0,045	0,213	41,2	10,1	47,9

cattle								
Rotted solid manure chicken/year	1460	1	1,3	0,8	0	19,0	11,7	0,0
Liquid manure cattle		1	0,5	0,07	0			
Milk sold	3675	1	0,56	0,09	0,14	20,6	3,3	5,1
Calves sold	200	0,8	2,45	0,6	0,2	3,9	1,0	0,3
Eggs sold	200,75	1	1,9	0,18	0,12	3,8	0,4	0,2
Chicken sold	3	20	3,43	0,48	0,13	2,1	0,3	0,1
Total						90,5	26,7	53,7
Total adapted to tropics	70%					63,37	18,71	37,60
/ ha	Area (ha)	14,90				4,25	1,25	2,52
Saldo (Input-Output)						1679,63	150,29	1153,40
/ ha and year						112,73	10,09	77,41

Including adjustment to tropical circumstances (estimated loss 20%)

In the stable balance the in- and outputs of the stable are summed up and are calculated in to model the overall nutrition balance and to possibly identify nutrition lacks in the stable which would require either less animals or additional sources of fodder.

6.1.2.2 Animal Husbandry

An important part of the organic farming principles is to analyze a farm with all its components. The animal husbandry plays an important role in the calculations of the overall farm in- and outputs. In the following table the animal specifications are indicated according to the inserted master data. Nevertheless, this table only provides an overview about the animals kept on the farm. In the section of stable balances only two types – cattle and chicken – have been inserted for the demonstration of the animal contribution to the farming system. The variety of animals is not limited and needs to be adapted to the specific case the simulation is used for.

Table 17: Animal Husbandry - Cattle, chicken, sheep, donkey

Animal Husbandry

Cattle

number	3
Dung per Cow (kg/y)	7500
liquid manure (l/day))	17,5
average weight cow (kg)	300
milk production (t/y)	3,5
% milk sold	100

Chicken

Number	40
Manure (kg/y)	36,5
Average weight (kg/chicken)	3
Egg production / day	0,55
% egg sold	100

Sheep

Number	N/A

Manure (kg/y)	N/A
Average weight (kg/sheep)	N/A
Wool production / season	N/A
% wool sold	N/A
% meat sold	N/A

Donkey

Number	N/A
Manure (kg/y)	N/A
Average weight (kg/donkey)	N/A
Donkeys sold / year	N/A

Sheep, donkey are not included in the nutrient balance; only for demonstration – this table can be enlarged in the model to the animal husbandry specifications of the specific case

6.1.2.3 Natural fencing & agroforestry

The natural fencing and agroforestry combines trees with shrubs (so called hedges). Together they create a protection for the farm against external influences and are the base for a microclimate in the ecosystem created. The hedges are planted every second meter around the farm and in the rows – these are the boundaries between the different cropping alleys. The aim is majorly to integrate fodder and medical plants for multiple purposes.

The trees are majorly meant to enlarge the income variety of the farm. The focus of this section is on the cultivation of trees for timber or fruits (this includes N-fixation plants e.g. Grevillea or Tree Lucerne). Beside all economic influences the trees have relevant ecological influences on the ecosystem. The trees are ensuring shade during extreme radiation periods and are deep rooting what implies an increase of the infiltration capacity and improvement of the soil structure and water holding capacity. In the following the focus is the production of the trees and its potential of contributing to the overall economic balance. Additionally, to the trees including in the hedge the simulation takes the trees that separate the rows into account.

Together these two components – hedges & trees – create a system that is in the following called agroforestry. This definition is according to this model and might differ from some definition of agroforestry found in the literature. Several advantages can be used through alley farming like (Kang, 2017):

- longer cropping period, more intensive cropping, and higher crop yields,
- regeneration of soil fertility,
- reduces requirements for external inputs of fertilizer.
-

In **Error! Reference source not found.** the configurations of the rows/alleys and hedges are indicated according to the previous inserted data in the user interface – marked grey. Additionally, the transition from the percentage of appearing trees is made to the exact numbers of planted trees. The simulation displays practically how many trees are on the farm. This is important for further calculations concerning the expected harvests.

In **Error! Reference source not found.** the area that is cover by agroforestry is divided in two parts. The first part describes the agroforestry area in the natural fence. The second integrates the agroforestry part in the rows that divide the different alleys from each other. In the table below only the outcome of the calculation is indicated. There are no calculations done about the contribution of hedges in the agroforestry system.

Table 18: Overview - Area Hedges and Rows

		ha	%
Length of border* (m)	1400		
Natural fence with agro-forestry planting area with 4m width (m^2)	5600	0,56	5,60
Area covered by agroforestry in alley system (m^2)	7452,36	0,75	7,45
Total agroforestry area (m^2)	**13142.36**	**1,31**	**13,1**
*for modelling purposes a rectangular farmland is assumed **not all planted trees are included; excluding the trees in row planting (these number can be found in the table below accordingly to the percentage of planted types of trees)			

Alley tree composition

	% of all trees	**number of trees**
Timber	20%	70
grevilea/tree luzerne	50%	175
Fruit	30%	105
Trees (planted each 4m)*		350
Hedges (planted each 2m)*		700
Total trees planted		**1300**

6.1.2.3.1 Trees

Out of the previous information and the inserted data in **Error! Reference source not found.**, it calculates the specifications, like amount of trees, yields and economic inputs and returns of the timber trees. It is meant to cultivate more than one species to increase the diversity and ensure higher resilience against natural hazards like pests or diseases. The calculations entail the division into three different timber species – e.g. Cordia Africana, Grevillea, Cypresses. In this case the necessary data of the local growing and selling conditions could not been gathered during the research. Nevertheless, the underlying equations are programmed that theoretically the model can simulate all outcomes – the same counts for the calculations of grevillea and fruit trees. The simulation for grevillea and tree Lucerne – **Error! Reference source not found.** – the same basic calculation principles are underlying. In **Error! Reference source not found.** the development of fruit trees is simulated. The model is integrating as many species as inserted in the user interface. Further the calculations are as in **Error! Reference source not found.** and **Error! Reference source not found.**.

Table 19: Timber trees – in-& output

Amount Species	**3**	**Cordia africana**	**Grevilliea**	**Cypressus**
Timber	20%	7%	7%	7%
Planted trees	140	46,67	46,67	46,67
Yield (t/ha)	N/A	N/A	N/A	N/A
Yield min (t/ha)	N/A	N/A	N/A	N/A
Yield max (t/ha)	N/A	N/A	N/A	N/A
Total yield (t/ha)	N/A	N/A	N/A	N/A
Seedlings (Birr)	370	100	200	70
Market price sales (Birr)	200	50	100	50

% yielded	10%	10%	10%	10%
yield sold (t)	N/A	N/A	N/A	N/A
Economic Input (Birr)	333	90	180	63
Economic return (Birr)	N/A	N/A	N/A	N/A

grey: to be filled by user

Table 20: Grevillea / Tree Lucerne – In- & output

Amount of species	5	Luzerne	Greviliea	Acazia	N/A	N/A
Grevillea / tree lucerne	50%	10%	10%	10%	10%	10%
Planted trees	350	116,67	116,67	N/A	N/A	N/A
Yield (t/ha)	N/A	N/A	N/A	N/A	N/A	N/A
Yield min (t/ha)	N/A	N/A	N/A	N/A	N/A	N/A
Yield max (t/ha)	N/A	N/A	N/A	N/A	N/A	N/A
Total yield (t/ha)	N/A	N/A	N/A	N/A	N/A	N/A
Seedlings (Birr)		20	20	10	N/A	10
Market price sales (Birr)		N/A	N/A	N/A	N/A	N/A
% yielded	0%	0%	0%	0%	N/A	0%
yield sold (t)	N/A	N/A	N/A	N/A	N/A	N/A
Economic Input (Birr)	50	20	20	10	N/A	10
Economic return (Birr)	N/A	N/A	N/A	N/A	N/A	N/A

grey: to be filled by user

Table 21: Fruit trees – composition and in- and output

amount Species	5	Mango	Papaya	Apple	Avocado	Banana
fruit of total (%)	30%	6%	6%	6%	6%	6%
Trees planted	210	42	42	42	42	42
Yield (t/ha)		8,85	37,00	N/A	N/A	N/A
Yield min (t/ha)		5,20	36,00	N/A	N/A	N/A
Yield max (t/ha)		12,50	38	N/A	N/A	N/A
Total yield (t/ha)		371,7	N/A	N/A	N/A	N/A
Seedlings (Birr)	460	50	10	200	100	100
Market price sales (Birr)	60	12	12	12	12	12
% yielded	100%	100%	100%	100%	100%	100%
yield sold (t)		371,7	N/A	N/A	N/A	N/A
Economic Input (Birr)		N/A	N/A	N/A	N/A	N/A
Economic return (Birr)		4460,4	N/A	N/A	N/A	N/A

grey: to be filled by user

6.1.2.3.2 Hedges

Beside the planted trees with a high impact on the total yield outcome the hedgerows have benefits for the whole production system that are less measurable. They are able to (Kang, 2017):

- provide green manure and mulch for companion crops,
- provide biologically fixed nitrogen for companion crops,

- improve soil conservation,
- create favourable conditions for beneficial soil organisms,
- provide high-protein fodder for livestock,
- provide staking material and/or firewood.

In the following the economic analysis of the agroforestry is done. That excludes the hedges and focuses on the trees with direct market products.

6.1.2.3.3 Economics

In the following table the detailed data form the previous tables is put together concerning the economic interest of input and return. It is important to mention that not all timber trees cut and fruits harvested will contribute to the economic balance since there will be some losses regarding the HH consumption. This is not integrated in the model and has to be included in a next step of the model development. Another factor that has to be taken into account concerning the simulation of tree harvests is the fact that beside the fruit trees take several years for recovery between different harvests.

The simulation for the agroforestry on farm level delivers a final overview about the financial contribution to the incomes and returns concerning the agroforestry. The investment costs are mainly seedlings and maintenance costs (maintenance is not taken into account in this section – see total gross margin). The return is depending on the tree planted – timber, fruits, fodder or firewood. The return of the tree cultivation is only calculated with the trees or fruits that are sold and go off-farm. Mainly these outcomes based on sold timber and fruits. Another important factor is the percentage of trees cut per year - only those can be taken into account. The fruits can be sold every year hundred percent if there is no HH consumption.

Table 22: Total economic balance of Natural Fence Production (focus trees)

	prices seed	economic input	market price sales	% yielded	yield sold	economic return
Timber	370	333	200	10%	0	0
Cordia	100	90	50	10%	0	0
Greviliea	200	180	100	10%	0	0
Cypressus	70	63	50	10%	0	0
Fruit (only fruit)	460	0	60	100%	0	4460,4
Mango	50	0	12	100%	371,7	4460,4
Papaya	10	0	12	100%	0	0
Apple	200	0	12	100%	0	0
Avocado	100	0	12	100%	0	0
Banana	100	0	12	100%	0	0
Tree Luzerne/ Grevillea	50	50	0,00	0%	0	0
Luzerne	20	20	0	0%	0	0
Greviliea	20	20	0	0%	0	0
Acazia	10	10	0	0%	0	0
Total input	N/A	N/A	N/A	N/A	N/A	N/A
Total return	N/A	N/A	N/A	N/A	N/A	N/A

Balance	N/A	N/A	N/A	N/A	N/A	N/A

6.1.2.4 Apiculture

To integrate beekeeping in the farming system is according to the organic principles reasonable in two manners. It enriches the ecosystems' diversity and ensures the pollination of several plants and trees. Another important factor is on the economic side. Beekeeping enables farmers to sell bee products – e.g. honey, propolis. The products can be processed or not depending on the labor availability. The honey can be sold in comb in case of low processing chances.

It is assumed that the beehives are integrated in the implementation costs of the farm and no further costs are required beside in case of honey processing. In **Error! Reference source not found.** below the basic parameter of bee keeping are indicated. This section can be treated as totally independent from other sectors since there is low interaction within the nutritional balances or other resources.

According to literature and expertise one bee hive is sufficient per hectare. This would imply in this particular case nine to ten bee hives. Nevertheless, beekeeping is strongly depending on several environmental and management factors:

- Weather conditions (precipitation and droughts)
- Hive location (availability of flower and nectar)
- Flower physiology (nectar content in flower)
- Pests
- Pesticides
- Extraction of honey / honey left for bees

Table 23: Apiculture

Apiculture

Total Area (ha)		9,2
Hive per hectare (number)		1
Hives on farm (number)		9
Population per hive (number)		15000-60000
Honey collected per hive (kg)		40-60*
Honey per year (kg)		360-540*
Price per kg (Birr; €)	100-150,-	4-6,-
Total economic return	**36000-81000,-**	**1440-3240,-**

*(Carbonar, Junior, Malaspina, & Polatto, 2016)

In the initial phase of the implementation it is important to guarantee a proper management since the installation of beehive and new colonies is a sensible topic. To consult expert knowledge in this concern will be advised.

6.1.3 Technical Infrastructure

The following two chapters are defining the need and outline of the technical infrastructure including the water management on the farm and buildings that are installed for several purposes. The water management is closely linked to the agricultural and HH practices. Because of this it is analyzed first. Included in these calculations are the roof top water harvesting calculations which are calculated with the covered area of the buildings.

6.1.3.1 Water in agriculture & HH

In the following chapter the simulation of the different components of the total water HH of the farm will be explained in different chapters. First the irrigation requirements will be analyzed according to the site-specific conditions. The different crop specific water needs are calculated in the FAO-software CropWat®. In a second step the potential for water harvesting on the site is simulated and analyzed concerning its potential to contribute to the overall water balance. In a third step the HH-water demand is simulated to analyze the farms potential and demands. Concluding the total water requirement for the farms and potential storage facilities are simulated.

6.1.3.1.1 Irrigation Requirement

In the following the irrigation requirements of the crops are indicated. Calculations have been made based on the FAO-software CropWat®. The most critical months are in the dry season (October - March) and the water shortage-peak is reached in February. Through the simulation, it is visible that there is no need for irrigation in the summer month when the monsoon is the strongest. This will be analyzed and explained in detail in the following.

CropWat® by the Food and Agriculture Organization (FAO) is a tool to estimate the water requirements of crops in their different growing stages according to the specific climatic conditions. The tool is in this case used to estimate the farms water needs for irrigation. These numbers are important due to the feasibility of the model farms' realization. Is the water requirement too high and the farm cannot compensate the different needs either through a water storage or pump capacities the farms feasibility has to be questioned. As follows this will be analyzed in detail according to the overall water requirements. The individual growing stages of the FAOs database have been checked and adapted to the crop varieties and growing conditions to better fit the local conditions. This has been done in literature research and in exchange with the expert Prof. Bernhard Freyer.

In CropWat® the data of the last 10 years of the climatic conditions for the weather station Bahir Dar, Ethiopia, have been used to forecast the conditions for the plant grow. Specification for CropWat® have been:

- Climatic weather data from Bahir Dar, Ethiopia
- Crops according to the CropWat® database
- Additional research on the local crop varieties concerning Initial stage, development stage, mid stage and ripening stage of certain local crops e.g. *nug and teff*

The calculations have been tried to be kept as close as possible to reality. A major division that has to be made is which kind of irrigation should be applied. Therefore, expert and local knowledge have contributed to which kind of irrigation should be applied for which crop. In **Error! Reference source not found.** the last column is indicating the sort of irrigation applied. The choices have been supported by the FAO irrigation manual (Allen, Pereira, Raes, & Smith, 1998).

Another indication that CropWat® needs as an input is the sort of irrigation. According to the expert knowledge the irrigation to 80% of the field capacity is applied (Tahir et al., 2014; Temesgen, Jensen, & Allen, 1999). This is due to the high soil composition variety in the area. Soil data has to be collected before planning a specific farm. Therefore, the irrigation requirements still have some uncertainties entailed which have to be adapted accordingly to the actual case. Additionally, the model is calculating with 80% of the CropWat®-calculated values. This is accordingly to the expert knowledge of Prof. Bernhard Freyer. The reduction to 80% of the values takes into account the buffer functions of an organic farm that is increasing the resilience through the soil water capacity. These values do not count for the transition period to organic farming. The models' aim is to model an organic farm. Transition calculations would need additional research capacities.

In the figure below the crop water requirements are displayed. The monthly water requirements taken into account in the monthly irrigation schedule are only the ones that are cultivated that season – all are scheduled in the figure below. The others are calculated for eventual changes in the crop rotation and hypothetical discussions. The most important outcome of the calculations is the flow requirement of a potential pump in l/s. The maximum peak requirements are in December, January and February with around 700-900mm perception/irrigation requirement. This equals a pump requirement in the peak month of 23 l/s. For this amount of water is a water source with enormous reservoir. This could be an aquifer. Accordingly, to the water expert Dr. Marou the Tana lake or the aquifer that is used for the city's water supply could both be feasible sources. The probability of the allowance to use those sources are not evaluated. In the following chapter the options to fulfill the water requirements will be explained in detail. In **Error! Reference source not found.** the higher requirements are indicated in red and lower requirements in green.

Table 24: Irrigation Requirement

AREAS	Crop	JUN	NOV	Jan	Feb	Mar	Apr	May	Jun	Juli	Aug	Sep	Oct	Nov	Dec	Planted JUNE	Planted November	Total	Sort of Irrigation
plot 1	Alfalfa	1		117,9	120,4	71,1	0	0	0	0	0	0	4,6	35,9	104,7	4,6	450	454,6	Sprinkler
	Alfalfa			117,9	120,4	71,1	0	0	0	0	0	0	4,6	35,9	104,7	4,6	450	454,6	Sprinkler
plot 2	Alfalfa			117,9	120,4	71,1	0	0	0	0	0	0	4,6	35,9	104,7	4,6	450	454,6	Sprinkler
	Alfalfa			117,9	120,4	71,1	0	0	0	0	0	0	4,6	35,9	104,7	4,6	450	454,6	Sprinkler
plot 3	Maize	1		150,5	112,8	11,9	0	0	0	0	0	0	0	19	107,5	0	401,7	401,7	Drip
	Faba beans		1	142,7	43,6	0	0	0	0	0	0	0	0	40,3	115,3	0	341,9	341,9	Sprinkler
plot 4	Potatoes	1		143,2	134,2	44,3	0	0	0	0	0	0	0	37,3	105,8	0	464,8	464,8	Drip
	Teff		1	117,7	8,9	0	0	0	0	0	0	0	0	84,1	115,4	0	326,1	326,1	Sprinkler
plot 5	Nug	1		100	100	60	0	0	0	0	0	0	0	35	90	0	385	385	Estimation
	Lupine		1	131,1	82	0	0	0	0	0	0	0	0	38,9	96,7	0	348,7	348,7	Sprinkler
plot 6	Wheat	1		143,8	120,8	22,9	0	0	0	0	0	0	0	14,3	82,4	0	384,2	384,2	Sprinkler
	Chickpea		1	124,1	126,7	147,8	84,2	0	0	0	0	0	37,4	49,8	7,5	37,4	540,1	577,5	Drip
plot 7	Teff	1		117,7	8,9	0	0	0	0	0	0	0	0	84,1	115,4	0	326,1	326,1	Sprinkler
	Sorghum		1	125,1	106,7	17,4	0	0	0	0	0	0	0	6,6	61,1	0	316,9	316,9	Sprinkler
plot 8	Nug	1		100	100	60	0	0	0	0	0	0	0	35	90	0	385	385	Estimation
	Beans		1	142,7	59,1	0	0	0	0	0	0	0	0	29,2	112,5	0	343,5	343,5	Drip
TOTAL (mm)				1019,2	667,8	307,4	84,2	0	0	0	0	0	9,2	320,7	717,9	55,8	6364	6419,8	
80% adj. tropics				815,36	534,24	245,92	67,36	0	0	0	0	0	7,36	256,56	574,32	44,64	5091,2	5135,84	
total (m)				0,815	0,668	0,307	0,084	0	0	0	0	0	0,009	0,3207	0,7179	0,056	6,364	6,420	
total l/m2				815,36	667,8	307,4	84,2	0	0	0	0	0	9,2	320,7	717,9	55,8	6364	6419,8	
total l/area				60763592	49766884	22908566	6274890	0	0	0	0	0	685617	23899730	53500519	4158419	474268422	478426841	
total m3				60764	49767	22909	6275	0	0	0	0	0	686	23900	53501	4158	474268	478427	
l/s				23	19	9	2	0	0	0	0	0	0	9	21	Pump requirement			*FAO manual

6.1.3.1.2 *Household Water Demand*

In this section the simulation of the HH water demand gives indication about the surplus of water that is needed for HH-purposes. The idea of the model farm is to use the rainfall water for HH purposes. In Figure 6: Household Water Demand & Rooftop Water Harvesting (RFWH) three main numbers are calculated:

1. **The water availability through rainfall** is assumed to be equal to the precipitation. This amount of water calculated by the rainfall data is available for the usage if there is enough storage capacity.
2. **The water demand for HH purposes** – accordingly to two different standard values (African Development Fund & World Health Organization):

- The HH water demand according to the WHO is about 20 liter per capita per day (l/c/d). A HH is estimated with six persons (Babulo et al., 2008). The AFD gives an indication about 15 l/c/s. Accordingly to both values water shortage for HH demands only occurs in February, the driest month – if a storage and water treatment can be applied. In all other month, the values are positive and precipitation surplus can contribute to irrigation.

3. The calculation of the **water balances for HH water** regarding rooftop water harvesting:

- In this section of Figure 6: Household Water Demand & Rooftop Water Harvesting (RFWH)the water balance between the water usage in the HH and the rooftop water harvesting is simulated and gives indication about the surplus or deficit needed to fulfil the basic water demands.

HH Water Demand - RFWH			Source: NISSEN et al.												
		Jan	Feb	März	Apr	Mai	Juni	Juli	Aug	Sep	Okt	Nov	Dez		
percipitation	mm	4	2	9	25	68	190	428	384	208	74	21	6	1419	
water availat	m3	3,86	1,93	8,69	24,15	65,69	183,54	413,45	370,94	200,93	71,48	20,29	5,80		
water availat	l	3864,00	1932,00	8694,00	24150,00	65688,00	183540,00	413448,00	370944,00	200928,00	71484,00	20286,00	5796,00	#########	
WHO (world helath organization)															
l/c/day	20														
l/HH/day	120														
m3/HH/day	0,12														
mm/HH/day	0,12														
mm/HH/mor	3,85	3,85	3,85	3,85	3,85	3,85	3,85	3,85	3,85	3,85	3,85	3,85	3,85	46,21	
l/hh/month	3720	3720	3720	3720	3720	3720	3720	3720	3720	3720	3720	3720	3720	44640	
ADF (african Development Fund															
l/c/day	15														
l/HH/day	90														
m3/HH/day	0,09														
mm/HH/day	0,09														
mm/HH/mor	2,89	2,89	2,89	2,89	2,89	2,89	2,89	2,89	2,89	2,89	2,89	2,89	2,89	34,66	
l/hh/month	2790	2790	2790	2790	2790	2790	2790	2790	2790	2790	2790	2790	2790	33480	
Water Harvesting difference/surplus															
WHO															
mm/HH/month		0,1	-1,9	5,1	21,1	64,1	186,1	424,1	380,1	204,1	70,1	17,1	2,1	1372,8	left for irrigation or other agricultural purposes
l/HH/month		144,0	-1788,0	4974,0	20430,0	61968,0	179820,0	409728,0	367224,0	197208,0	67764,0	16566,0	2076,0	1326114,0	left for irrigation or other agricultural purposes
ADF (african Development Fund															
mm/HH/month		1,1	-0,9	6,1	22,1	65,1	187,1	425,1	381,1	205,1	71,1	18,1	3,1	1384,3	left for irrigation or other agricultural purposes
l/HH/month		1074,0	-858,0	5904,0	21360,0	62898,0	180750,0	410658,0	368154,0	198138,0	68694,0	17496,0	3006,0	1337274,0	left for irrigation or other agricultural purposes
average water balance (l/HH/month)		681	-1323	5439	20895	62433	180285	410193	367689	197673	68229	17031	2541	1331694	

Figure 6: Household Water Demand & Rooftop Water Harvesting (RFWH)

6.1.3.1.3 Water Harvesting

In this section the water harvesting is described. For the water harvesting the main input data is the rainfall data. The precipitation is the main input for the water harvesting structures. In the following the precipitation, the Household-water-demands, the rooftop water harvesting, the courtyard water harvesting potential will be calculated with the irrigation requirement. In the end the water balance will show which amount of additional water is necessary to fulfill the crop water requirements.

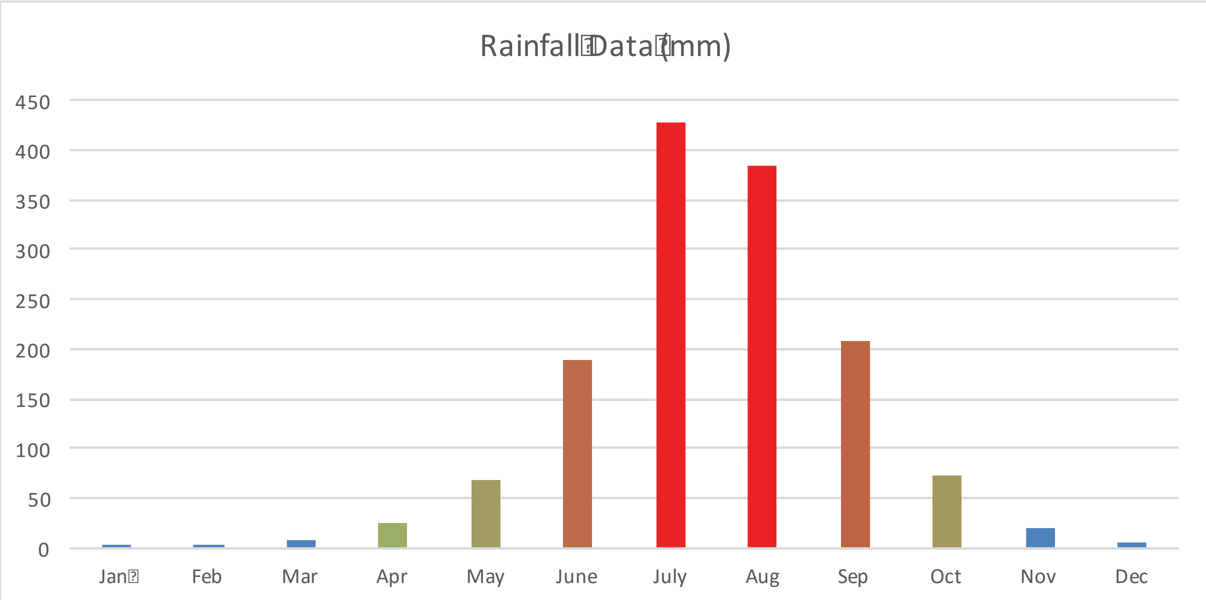


Figure 7: Rainfall Data – Bahir Dar, Ethiopia

The rainfall data is characterized by one big rainy season in summer. Monthly peak precipitation of above 400mm in July are the maximum in Bahir Dar region – with a 10-year average. In the rainy season from June to September about 1200mm are potential accumulated precipitations.

In the section of precipitation, the amount of rainfall is indicated accordingly to the FAO data of the CropWat® for the region Bahir Dar, Ethiopia. The precipitation is indicated accumulated for the whole year since interest is the potential of the precipitation to cover the crop water requirements.

Possible measures include the installation of water harvesting, storage and – in case of HH water use – treatment facilities. Therefore, calculations are done with the planned infrastructure. The rooftop area of this infrastructure is taken into account as area to collect and divert water to storage facilities. That way potentially lost water can be caught and used in dry periods for irrigation purposes. Additionally, the court yard – the space between the buildings – can also contribute to that kind of water harvesting. The rooftop harvesting is calculated to collect 95-100% of the rainfall and for the courtyard it is calculated with 10-25% because of infiltration and other losses (Nissen-Petersen, 2007). The peak runoff is also calculated so that the capacity can be calculated and the water harvesting infrastructure can be adapted to the maximum amounts.

In the following section the total irrigation water is calculated. All sources are summed up and deliver a surplus of 196.900 liter/month in average. With this calculation the storage can be calculated. Therefore, it is assumed that the storage facility will be squared. This can be adapted in a later stage of the model development. The overall capacity of the storage is estimated with 2363m^3. This capacity could buffer all drought extremes and heavy rainfall events.

Table 25: Water Harvesting Overview – Contribution to HH, Irrigation

Precipitation	mm/ m²
Rainfall	1419
average (monthly)	118,25
max (monthly)	428

Roof Top Water Harvesting

			Purpose
Roof Top Area (m²)	966,00		
Prec. Overall (m)	1,42		
max (m)	0,43		
amount runoff (overall) m³; liter	1370,75	1370754	HH
amount runoff (peak) m³: liter	413,45	413448	HH

Courtyard Water Harvesting

Courtyard Area (m²)	1458,00		
Prec. Overall (m)	1,42		
max (m)	0,43		
overall runoff with 10-25% (overall) m³/liter	362,06	362057,85	Irrigation
min (10%) m³/liter	206,89	206890,2	
max (25%) m³/liter	517,23	517225,5	
runoff with 10-25% (peak) m³/liter	109,20	109204,20	Irrigation
min (10%) m³/liter	62,40	62402,40	
max (25%) m³/liter	156,01	156006,00	

Total water availability

RTWH	m³	liter	
per year	1370,75	1370754,00	HH (surplus for irrigation)
average	114,23	114229,50	HH (surplus for irrigation)
peak	413,45	413448,00	HH (surplus for irrigation)
CWH (average)			
average (month)	362,06	362057,85	Irrigation
peak (month)	109,20	109204,20	Irrigation

Irrigation water

Surplus RTWH	liter/year	liter/month	**Comment**
Following WHO-standards	1326114	110510	
Following ADF-standards	1337274	111440	
Average	2000331	166694	averaged scenario WHO - ADF
Average CWH	362058	30171	Averaged scenario for the whole year
Total available water	**2362389**	**196866**	

Water Storage Facility

Total water stored (liter)	2362389

total water stored (m^3)	2362,39
advised depth of water storage (m)	3
area of water storage (m^2)	787,46

6.1.3.1.4 Water Requirement Total

In this section the previous chapters will be brought together to create an overall overview about the water situation on the farm. The table considers the HH water demands (for the two standard values), the crop water requirements and the water harvesting balance. According to those indicators the total water balance is calculated and the pump requirements are calculated.

For the HH water demand there only is demand in February for pumping but the rest of the year is sufficient supply. The crop water requirements have different levels of water demand. Irrigation is only needed in the winter month from October onwards till March/April depending on the crops cultivated. For the irrigation, different methods have been estimated – sprinkler and drip irrigation – depending on the type of crop. The amounts that need to be irrigated cannot be covered by the water harvesting structures.

Translated to pump requirements the water supply needs in peak months (e.g. February) a pump with 23 l/s capacity. Since this pump capacity is very high and installments and maintenance would extend the budget, the necessity to think about other options has high priority.

A feasible alternative would be given with the extension of the storage facility. That way water could be pumped up continuously during the year and when the droughts arrive water already stored could be used to irrigate. In case this option will be chosen new calculations have to be made including the data below. These calculations are not integrated in this model.

Water Requirement total

Water requirement HH	Jan	Feb	März	Apr	Mai	Juni	Juli	Aug	Sep	Okt	Nov	Dez	Total
WHO													
mm/HH/month	3,85	3,85	3,85	3,85	3,85	3,85	3,85	3,85	3,85	3,85	3,85	3,85	46,21
l/hh/month	3720,00	3720,00	3720,00	3720,00	3720,00	3720,00	3720,00	3720,00	3720,00	3720,00	3720,00	3720,00	44640,00
ADF													
mm/HH/month	2,89	2,89	2,89	2,89	2,89	2,89	2,89	2,89	2,89	2,89	2,89	2,89	34,66
l/hh/month	2790,00	2790,00	2790,00	2790,00	2790,00	2790,00	2790,00	2790,00	2790,00	2790,00	2790,00	2790,00	33480,00
Average	**1629,18**	**1629,18**	**1629,18**	**1629,18**	**1629,18**	**1629,18**	**1629,18**	**1629,18**	**1629,18**	**1629,18**	**1629,18**	**1629,18**	**19550,22**

Water Requirement Crops	Jan	Feb	Mar	Apr	May	Jun	Juli	Aug	Sep	Oct	Nov	Dec	Total	Planted JUNE	Planted November
Total (m3)	59499,7	51592,7	13153,4	0,0	0,0	0,0	0,0	0,0	0,0	3472,8	24250,0	58694,8	458365,1	3472,8	454892,3
Total (l)	59499671,3	51592713,5	13153421,8	0,0	0,0	0,0	0,0	0,0	0,0	3472801,5	24249991,3	58694816,0	210663415,3	34728015	4548922763,6
SUM (Calculated with	Jan	Feb	März	Apr	Mai	Juni	Juli	Aug	Sep	Okt	Nov	Dez	Total		
Liter	59501300,46	51594342,64	13155051,00	1629,18	1629,18	1629,18	1629,18	1629,18	1629,18	3474430,6	24251620,46	58696445,18	210682965,49		

Rainwater Harvesting Balance

litre/month	681	-1323	5439	20895	62433	180285	410193	367689	197673	68229	17031	2541	1331694
m3/month	0,681	-1,323	5,439	20,895	62,433	180,285	410,193	367,689	197,673	68,229	17,031	2,541	1331,694

Balance/need for extraction

															Average per day	daily peak (Jan)	daily water extractiong in peak time (Dez-Mar)
litre/ month	59498990,3	51594036,5	13147982,8	-20895,0	-62433,0	-180285,0	-410193,0	-367689,0	-197673,0	3404572,5	24232960,3	58692275,0	209331649,3	litre	573511,37	1983299,68	1524444,04
m3/momth	59499,0	51594,0	13148,0	-20,9	-62,4	-180,3	-410,2	-367,7	-197,7	3404,6	24233,0	58692,3	209331,6	m3	573,51	1983,30	1524,44
l/s	23	20	5	0	0	0	0	0	0	1	9	23	pump requirement				

Figure 8: Water Requirement - Total

6.1.3.2 Buildings

As indicated in Figure 5 infrastructure of the farm includes water storage, compost, biogas, housing, storage & processing, stables (cow & chicken) and a teaching area. In **Error! Reference source not found.** the user need to fill in the dimensions of the buildings. Since the dimensions are only used for the calculations of the area there is no need further indication of height or depth (e.g. water storage). The interest is to identify the area that is covered by buildings and could potentially contribute to the rainwater harvesting – see *Water Harvesting.*

Table 26: Infrastructure specifications

Housing	**m** (m^2**)**	**Water storage**	**m** (m^2**)**	**Cows/Stable**	**m** (m^2**)**	**Chicken**	**m** (m^2**)**
length	10	length	20	length	30	length	10
width	10	width	20	width	10	width	10
covered	100	covered		covered	100	covered	50
total	**100**	**total**	**400**	**total**	**300**	**total**	**100**
Teaching area	**m** (m^2**)**	**Storage, Processing**	**m** (m^2**)**	**Compost**	**m** (m^2**)**	**Biogas**	**m** (m^2**)**
length	20	length	20	length	10	length	4
width	10	width	20	width	10	width	4
covered	200	covered	400	covered	100	covered	16
total	**200**	**total**	**400**	**total**	**100**	**total**	**16**

grey: to be filled by user

The water storage is based on certain irrigation and precipitation calculations. It aims to cope with certain water insecurities during the dry season and unexpected temporary droughts. The water storage is refilled during the monsoon to prevent occurring water losses. This will be discussed in the chapter of water management.

The compost is contributing to the nutrition balance of the farm through reusing the organic waste of the HH and processing to regain the nutrients. It is a key element in the organic farming practices. Other organic wastes contribute to the biogas that delivers energy for the HH.

The housing is a fixed dimension in the model that is needed depending on the amount of families living and sharing the farm. It is set with 100m^2 per family of five to seven HH-members. Linked to the housing is the construction of a storage & processing unit which is aimed to be close to the housing. Depending on the different crops and produces that are delivered by the farm the storage and processing facility needs to be adapted. That can be done in the user interface in the beginning of the program. In this case the farm additionally aims at being an excellence center what includes the capacities to give trainings and lectures about the on farm activities. Therefore, in this case the infrastructure is including a “training and teaching facility”.

Finally, the storage for the cows and potential chicken taken into account. Depending on the number of animals the storage facility is adapting. Again, this is adapted according to the case and the settings can be changed in the user interface.

Table 27: Infrastructure

	m2	%*	
Total area	**2424**	**2,42**	Comment The length of the infrastructure is calculated by the model in a manner that minimizes arable land losses and keeps a rectangular shape of the arable fields. This is only for calculation and can be adapted in the implementation. Important is that this calculation delivers the amount of area that is occupied by buildings.
Infrastructure width (m)	492		
Infrastructure length (m)	5**		
Housing	100	0,10	
Water storage	400	0,40	
Cows stable	300	0,30	
Chicken	100	0,10	
Storage, Processing	400	0,40	
Compost	100	0,10	
Biogas	16	0,02	
Teaching area, Sanitary, Shop	200	0,20	
Free space area (court yard)	808	0,81	

*% of total farm area
**practical value for the model to be able to calculate

6.1.4 Economics

In the chapter Economics, the different outputs of the farm that are meant for sales e.g. cash crops, meat products, animals or animal products. The chapter is divided in two main parts. First the field production will be simulated. This includes all products that are sold after harvest – this is including processed products. Second the stable production is put into relation to the market outcomes. These simulations are integrated in the total gross margin calculations.

The master data of **Error! Reference source not found.** is filled in with the user interface (grey). Including the data of the crop rotation the calculations for the total economic field balance can be done.

The master data for the stable production are taken out of *Stable Balances* ***Error! Reference source not found.***.

Table 28: Economics of in- & outputs (Crops, fertilizer, stable products)

Economics

		INPUT (Birr/kg)	**SALES (Birr/kg)**
Crop		Seeds	Yield
Cash Crops / HH - use	Maize	18	5
	Potatoes	30	5,5
	Wheat	8	8
	sorghum	11	11
	Teff	12	15
Legumes	Vicia hirsuta	20	0
	Faba beans	10	11
	Lupine	50	0
	Nug	12	20
	Alfalfa	40	0
	Chickpea	12	13
	Beans	11	11
Vegetables	N/A	N/A	N/A
	N/A	N/A	N/A
	N/A	N/A	N/A
	N/A	N/A	N/A

Fertilizer	**Costs per kg** (Birr)
Phosphorus	N/A
Lime	N/A
Pesticides	N/A

Animal products	**Market Prices** (BIrr)
Milk (per litre)	N/A
Eggs (per piece)	N/A
Meat (beef; per kg)	N/A
Meat (chicken per piece)	N/A

This is a simulation based on the model case for demonstration and can be adapted model development.

6.1.4.1.1 Field Production

The section Economics – Field Production will give an overview about the calculations concerning the different economic factors. The focus of this table is the calculation of direct agricultural expenses and earnings. The aim is to model certain in- and outflows for agricultural production. Excluded from these calculations are labor and technology/machinery. **Error! Reference source not found.** displays an overview of the economic connections. The model includes costs, returns and an overall balance of the agricultural production. The performing crops are displayed and accordingly to the percentage of sales the economic return is calculated.

Table 29: Economics

One Year										Cost						Return							Balance	
AREAS	Crop	JUNE (planted=1)	NOVEMBER (planted=1)	seeds kg/ha	Area ha	Seeds bought	Total Seeds (kg)		seeds cultivated	Amount per kg		Total Cost / ha		Total cost		Yield (t)		Sold			Total Output		Balance	
							JUNE	NOV	%	BIR.	€	BIRR	€	BIRR	€	JUN	NOV	%	t	kg	BIRR	€	BIRR	€
plot 1	Alfalfa	1		10,00	0,93	0	9,32	0	100	40	1,60	400	16	372,62	14,90	5,59	0	0	0	0	0	0	-372,62	-14,90
	Alfalfa			10,00	0,93	0	0	0	100	40	1,60	400	16	0	0	0	0	0	0	0	0	0	0	0
plot 2	Alfalfa			10,00	0,93	0	0	0	100	40	1,60	400	16	0	0	0	0	0	0	0	0	0	0	0
	Alfalfa			10,00	0,93	0	0	0	100	40	1,60	400	16	0	0	0	0	0	0	0	0	0	0	0
plot 3	Maize	1		27,50	0,93	0	25,62	0,00	100	18	0,72	495	19,8	461,12	18,44	4,66	0,00	1,00	4,66	4657	23288,64	931,55	22827,52	913,10
	Faba beans		1	150,00	0,93	0,10	0,00	139,73	90	10	0,40	1.500	60	1.397	55,89	0	1,86	0,90	1,68	1676	18444,60	737,78	17047,28	681,89
plot 4	Potatoes	1		2000,00	0,93	0,10	1863,09	0,00	90	30	1,20	60.000	2.400	55.893	2.236	9,32	0	0,90	8,38	8383	46111,50	1844,46	-9781,23	-391,25
	Teff		1	9,00	0,93	0,10	0,00	8,38	90	12	0,48	108	4,32	100,61	4,02	0	1,86	1,00	1,86	1863	27946,36	1117,85	27845,76	1113,83
plot 5	Nug	1		75,00	0,93	0,10	69,87	0,00	90	50	2	3.750	150	3.493	139,73	0,75	0	0	0	0	0	0	-3493,30	-139,73
	Lupine		1	12,00	0,93	0,10	0,00	11,18	90	12	0,48	144	5,76	134,14	5,37	0	2,10	1,0	2,1	2095	41919,55	1676,78	41785,40	1671,42
plot 6	Wheat	1		125,00	0,93	0,10	116,44	0,00	90	8	0,32	1.000	40,00	931,55	37,26	3,26	0	1,00	3,26	3260	26083,27	1043,33	25151,73	1006,07
	Chickpea		1	100,00	0,93	0,10	0,00	93,15	90	12	0,48	1.200	48,00	1.117	44,71	0,00	1,30	1,00	1,30	1304	16954,13	678,17	15836,27	633,45
plot 7	Teff	1		10,00	0,93	0,10	9,32	0,00	90	15	0,60	150	6,00	139,73	5,59	1,86	0,00	1,00	1,86	1863	27946,36	1117,85	27806,63	1112,27
	Sorghum		1	12,00	0,93	0,10	0,00	11,18	90	11	0,44	132	5,28	122,96	4,92	0,00	3,73	1,00	3,73	3726	40988,00	1639,52	40865,04	1634,60
plot 8	Nug	1		75,00	0,93	0,10	69,87	0,00	90	20	0,80	1.500	60,00	1.397	55,89	0,75	0,00	1,00	0,75	745	14904	596,19	13507,41	540,30
	Beans		1	150,00	0,93	0,10	0,00	139,73	90	11	0,44	1.650	66,00	1.537	61,48	0,00	1,07	1,00	1,07	1071	11784	471,36	10247,00	409,88
TOTAL (BIRR : €)														67077,1	2683,10						296371	11854	229272,9	9170,92

The first part of the table is indicating the amount of seeds that are needed for the cultivation of the individual plot. Additionally, the table divides between the seed material that is bought and that is kept for storage. The crop rotation is the same as explained earlier – *Crop Rotation* – and is automatically linked to the table of the user interface.

Table 30: Economic balance –Field production (Crop rotation and costs)

One Year										**Cost**					
AREAS	**Crop**	**JUN**	**NOV**	**seeds kg/ha**	**Area ha**	**Seeds bought**	**Total Seeds (kg)**		**seeds cultivated**	**Amount per kg**		**Total Cost / ha**		**Total cost**	
							JUN	**NOV**	**%**	**BIR.**	**€**	**BIRR**	**€**	**BIRR**	**€**
plot 1	Alfalfa	1		10	0,93	0,00	9,32	0,00	100	40	1,6	400	16	372,62	14,90
	Alfalfa			10	0,93	0,00	0,00	0,00	100	40	1,6	400	16	0,00	0,00
plot 2	Alfalfa			10	0,93	0,00	0,00	0,00	100	40	1,6	400	16	0,00	0,00
	Alfalfa			10	0,93	0,00	0,00	0,00	100	40	1,6	400	16	0,00	0,00
plot 3	Maize	1		28	0,93	0,00	25,62	0,00	100	18	0,7	495	19,8	461,1	18,44
	Faba beans		1	150	0,93	0,10	0,00	139,73	90	10	0,4	1500	60	1397	55,89
plot 4	Potatoes	1		2000	0,93	0,10	1863,09	0,00	90	30	1,2	60	2400	55.893	2.236
	Teff		1	9	0,93	0,10	0,00	8,38	90	12	0,48	108	4,32	100,61	4,02
plot 5	Nug	1		75	0,93	0,10	69,87	0,00	90	50	2	3750	150	3.493	139,73
	Lupine		1	12	0,93	0,10	0,00	11,18	90	12	0,48	144	5,76	134,14	5,37
plot 6	Wheat	1		125	0,93	0,10	116,44	0,00	90	8	0,32	1000	40	931,55	37,26
	Chickpea		1	100	0,93	0,10	0,00	93,15	90	12	0,48	1200	48	1.117	44,71
plot 7	Teff	1		10	0,93	0,10	9,32	0,00	90	15	0,6	150	6	139,73	5,59
	Sorghum		1	12	0,93	0,10	0,00	11,18	90	11	0,44	132,00	5,28	122,96	4,92
plot 8	Nug	1		75	0,93	0,10	69,87	0,00	90	20	0,8	1500	60	1.397	55,89
	Beans		1	150	0,93	0,10	0,00	139,73	90	11	0,44	1650	66	1.537	61,48
TOTAL (BIRR : €)														67077,1	2683,10

The second part of the table as displayed in **Error! Reference source not found.** indicates the costs invested in agricultural production. These numbers focus on the costs that are linked to the agricultural production and the seed material. The calculations include indications about the costs per hectare. In a next step the price for the seeds linked to the amount of seeds is than calculating the investment costs for this particular model farm. To better compare the different costs for certain crops the price per hectare is calculated.

Table 31: Economic Balance – Field production (return and total balance)

	Return							**Balance**	
Crop	**Yield (t)**		**Sold**			**Total Output**		**Balance**	
	JUNE	**NOV**	**%**	**t**	**kg**	**BIRR**	**€**	**BIRR**	**€**
Alfalfa	5,59	0	0,00	0,00	0,00	0,00	0,00	-372,62	-14,90
Alfalfa	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Alfalfa	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Alfalfa	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Maize	4,66	0,00	1,00	4,66	4657	23288,64	931,55	22827,52	913,10
Faba beans	0,00	1,86	0,90	1,68	1676	18444,60	737,78	17047,28	681,89
Potatoes	9,32	0,00	0,90	8,38	8383	46111,50	1844,46	-9781,23	-391,25
Teff	0,00	1,86	1,00	1,86	1863	27946,36	1117,85	27845,76	1113,83
Nug	0,75	0,00	0,00	0,00	0,00	0,00	0,00	-3493,30	-139,73
Lupine	0,00	2,10	1,00	2,10	2095	41919,55	1676,78	41785,40	1671,42
Wheat	3,26	0,00	1,00	3,26	3260	26083,27	1043,33	25151,73	1006,07
Chickpea	0,00	1,30	1,00	1,30	1304	16954,13	678,17	15836,27	633,45
Teff	1,86	0,00	1,00	1,86	1863	27946,36	1117,85	27806,63	1112,27
Sorghum	0,00	3,73	1,00	3,73	3726	40988,00	1639,52	40865,04	1634,60
Nug	0,75	0,00	1,00	0,75	745	14904	596,19	13507,41	540,30
Beans	0,00	1,07	1,00	1,07	1071	11784	471,36	10247,00	409,88
Total						**296371**	**11854**	**229272,9**	**9170,92**

The third step in the calculation of the field economics is focusing on the returns as displayed **Error! Reference source not found.**. The numbers are calculated with the certain amount of yield that is collected and the percentage of yield that is meant to be sold. With the initial data input about the market prices of certain crops the calculations can easily be adapted to certain local conditions. E.g. it is easily adapted to differing market prices in different years. The last block of the return calculations is about the monetary output of the agricultural return.

The last block in this section deals with the balance costs and return. The balance is calculated following the basic equation:

RETURN – COSTS = BALANCE

This shows an end-balance at the bottom of the block. The end-balance need to be positive to make the whole system profitable since agricultural productivity is the most important pillar of the model farm. And in further usage and different cases this source of income defines the indicator for potential difference to conventional farming systems by delivering a higher outcome (depending on the site-specific conditions).

6.1.4.1.2 *Animal Production*

The stable delivers products contributing to the overall farm economics. The model takes the given information of the user interface and simulates the yearly outcomes of the stable. This includes direct products like calves, chicken, milk and eggs which can be sold without processing as well as meat products or dairy products. This is depending on the individual stable constitution. The model is requiring the general data about how many animals and their products.

For the meat production, the model is more complex. Two scenarios can be applied here. The first one entails a direct meat processing including a butcher on the farm. The second scenario – with a higher likelihood – is the direct sale of living animals to a butcher shop. The first scenario will be included in the calculations in the model. In a later development stage of the model there are aimed to be two different options to choose when entering the animal husbandry data in the user interface.

The second model includes the basic economic value of the animals in a system. Through this basic approach, the simulation is focusing the nutritional contribution and losses through animal. The highest impact on the economic balance of a farm like it is modeled in this case is the milk. Based on the sufficient nutrition of the cows the milk production can be increased up to 3,5 t/a (tons per year). This way the farm income can be increased significantly.

The tables are divided in the different animals to analyze the implementation of animals separately. These table do not simulate the nutritional contribution to the farm. This can be found in chapter *Stable Balances.*

Table 32: Economic Return Animal Husbandry

Cattle	
number	3

average weight cow (kg)	300	
Price per kg meat (Birr; €)	100	4
Total return cow (assuming 60% weight of average are sold)	18000	720
milk production (l/y)	3500	
% milk sold	100	
Price per liter milk (Birr; €)	10	0,4
Total return milk sold (Birr; €)	35000	1400
Total return cattle (Birr; €) (assuming one cow sold per year)	**53000**	**2120**

Chicken

Number	40	
Average weight (kg/chicken)	3	
Price per chicken	300	12
Total return chicken (Birr, €) (assuming 10 chicken sold per year)	3000	120
Egg production / day	0,55	
% egg sold	100	
Price per egg (Birr; €)	2	0,08
Total return eggs sold per year (Birr, €)	3372	135
Total return chicken (Birr; €)	**6372**	**255**

Sheep

Number	N/A	
Average weight (kg/sheep)	N/A	
% meat sold	N/A	
Price meat per kg (Birr, kg)	N/A	N/A

Total return sheep (Birr, €) (assuming X sheep sold per year)	N/A	N/A
Wool production / season	N/A	
% wool sold	N/A	
Price per kg wool (Birr; €)	N/A	N/A
Total return kg wool sold per year (Birr, €)	N/A	N/A
Total return sheep (Birr; €)	N/A	N/A

Donkey

Number	N/A	
Donkeys sold / year	N/A	
Price per donkey	N/A	
Total return donkey	N/A	N/A

N/A: data to be collected

6.2 Participation

Two results are described here to demonstrate the outcomes of the participatory process. In the section of the *Organic Advisory Group* the participatory modelling process is described along the workshops and meetings that have been done throughout the field work. In the second step the gathered results of the gender workshops will be described. The results have not been integrated in the *Model Creation.* These results tackle the objective to find pathways for innovations and to widen the transdisciplinary field of an organic farm. This mainly has consequences for the setup and the way how the farm is implemented.

6.2.1 Organic Advisory Group

In the following sections the results of the organic advisory group are described. The aim of that group was to create an inter- and transdisciplinary learning and exchange of knowledge process with guiding and enhancing different disciplines in a modelling process. According to those different stages the group has been working on, the results can best be described by the workshops and meetings that accompanied the modelling process. A lot of data input results have already been integrated in the *Model Creation* where it has been explained which data needed to be filled in the user interface for the proper modelling according to local conditions. In the following the participation and the way how this participation has been designed is explained. The first meetings refer to the **Parameterization** of the model. There, data input is generated and the understanding of the different interlinked disciplines has been worked on. The later meetings – especially the last one – concentrates on the model **Evaluation.** In those meetings the logic and workability has been explained and counterchecked with the participants. Through this evaluation the participants had the chance to again get an overview and insights about different topics and their interactions. Additionally, they were asked to look beyond the information given to them concerning these interactions and verify them for themselves.

6.2.1.1 The Workshops

In this part of the chapter the different meetings will be described including the methods that have been used, the challenges of the group, the behavior of the participants and the facilitator and the topics and content that has been gathered meanwhile. Within this spectrum, the paragraph deals with different subjects that could be covered by the group. It ranges from soil and water management to multiple use of water through different economic analysis of the status quo on the market concerning seed and crop prices and several more. Within this cooperation and the planning of the farm it has been crucial that the local knowledge infiltrated in the overall overview of the facilitator. Through this the final planning tool had been adjusted and calculations were aimed to be adapted adequately.

6.2.1.1.1 1st Workshop

The **first meeting** was meant to clarify all framework issues for the group – on the one side the question what the group is asking to be able to participate and on the other side what does the facilitator respectively the project management is expecting. The first overview about the expertise showed the coverage of the following topics:

- Agriculture (economics & natural science)
- Horticulture
- Water management
- Fishery
- Soil science

This opened a discussion about missing expertise in the group. The group came to the conclusion that essential expertise is missing concerning the social and legal framework and organic farming. The integration of these expertises is assumed to be necessary to develop a long-term project with a certain impact. This enlarges the complexity but at the same time the resilience of the model farm as an institution of learning and exchange. The better the model farm integrates external system like the legal framework or the better the farm is integrated in the social system it can on the one side reach a higher impact and has on the other side higher potential to be accepted by the community. It has been decided that every member invites

Picture 3: Organic Advisory Group (throughout the several meetings)

for the next meeting another colleague from another discipline.

Further the discussion about the different disciplines opened a discourse about added value by every field of expertise. The discussion about how fishery could be integrated in the farm led to the issues of water management. The water basin that might be implemented could be used additionally for the cultivation of fishes serving an additional source of income and subsistence.

6.2.1.1.2 2nd Workshop

The **second meeting** has been used to get to know each other better. With the focus on the project and without any briefing about what will happen in the OAG the members were asked to formulate their motivation, expectations and the challenges they assume that will occur.

The chosen setting where everybody is comfortable with engaged the members to share their thoughts if wanted. The members had 15 minutes to think on each topic – motivation, expectations and challenges – and to take notes. Additionally, the participants were asked to classify different potential areas that have been preselected by with support of the *Small Scale & Micro Irrigation Support Project (SMIS)* and *Dr. Marou (WLRC).* Aim has been to find two potential options for the implementation of the farm.

After each 15 minutes the members had the chance to share their thoughts. Apparently, it happened that every member shared their thoughts to each time. Later in the feedback round it has been mentioned that through the fact that it has not been obligatory to share the thoughts it was for the members easier to open up and to talk. The first sharing had been a hurdle for the first speaker since he didn't know all the members. Nevertheless, his sharing engaged other participants to join and share their thoughts. This created a open atmosphere everybody felt less pressure to participate and the sharing of even sensitive topics has not been a problem. This surrounding seemed also to be created through the facilitators attitude of valuing the contribution of the individual members. Improvements of the facilitator could be found in the formulation of the tasks. Apparently, the formulations have been to vague and needed to be clarified in the situations. Additionally, the motivation, expectations and challenges of the facilitator should also be shared. This has been added after the feedback of the participants.

The outcome of this second meeting is listed in the table below. The table shows the individual statements of the participants concerning their opinions.

Motivation. The biggest motivation of the participants has been rooted in their individual interest. This can be the potential of a job opportunity through participating or increasing the personal knowledge about organic farming. The issues of improving the natural conditions and creating an alternative for common conventional practices came later in the discussion and are assumed to be more rational conclusions about what a motivation should be when you join the group. These arguments came up when the group discussed about what could be attractive for new participants to join. The topic will be discussed in detailed in the chapter *Conclusion for development*

Expectations. The participants expect to learn about organic farming and also about the implementation of a project like this. As most important the group identified the role of “modern organic farming” as a mentor and a role model for future agricultural practice and farmers' independence and subsistence. Within the discussion, the diversity of organic farming practices got topic. This makes aware of the need for a clear discussion and definition about how organic farming is understood in the OAG and what the principles are behind that particular agricultural practice.

Challenges. In this phase of the planning the main concerns and doubts have been about the financial situation of the whole project. Another major concern is linked to the identification of suitable land and furthermore the property issues about the land. The Ethiopian situation concerning land is seen critical because there is no property of land. All land in governmental and the most land that is given to project is linked to companies or organizations that are highly profitable. As far as these challenges are eliminated or solved the participants do not see any further obstacles that can hinder the realization.

	Motivation	Expectations	Challenges
Professional Level	• ET economic dependency on agriculture • Scientific reasons • Increase productivity through diversity • OF as strategy to cope with CC • Learn about the OF principles • Sustainability of farming→OM increase • Dependency of artificial products • Soil fertility • Pollution reduction • Integration of aquatic systems • Alternatives for chemical farming	• Need to see organic farming practices • Replication of good practices • Modern organic farming design **implementation as mentor** • Smallholder application • Knowledge • Practice • Knowledge transfer concerning the different organic farming issues	• The identification of suitable land • Administrative dalliances • Financial activities • Land identification and administration

Interesting in especially the last point of the challenges is the matter of fact that the only hindrance is an external one. To find consent in a governmental institution like Bahir Dar University – here seen as system – is often complex. It might be considered as a positive indicator if the members of the group do not see any internal obstacles since they know the system better than external parties like the facilitator or any other external.

The last issue of the second meeting has been the decision about potential areas for the farm land. As described in Annex: *Location identification process* the analysis of potential farm land areas has been supported by the *Small Scale & Micro Irrigation Project (SMIS)* and *Dr. Marou* (*WLRC*). The support has been mainly on natural and scientific preferences and conditions. These predefined areas were supposed to be classified by the OAG since the local knowledge of the areas around Bahir Dar regarding social and infrastructural issues is better covered by the OAG. The outcome of this classification is shown in the map below (small red circles). One region of interest is in direction of and close to Zegey and the other one is in the direction of Meshenti – both in the South West of Bahir Dar.

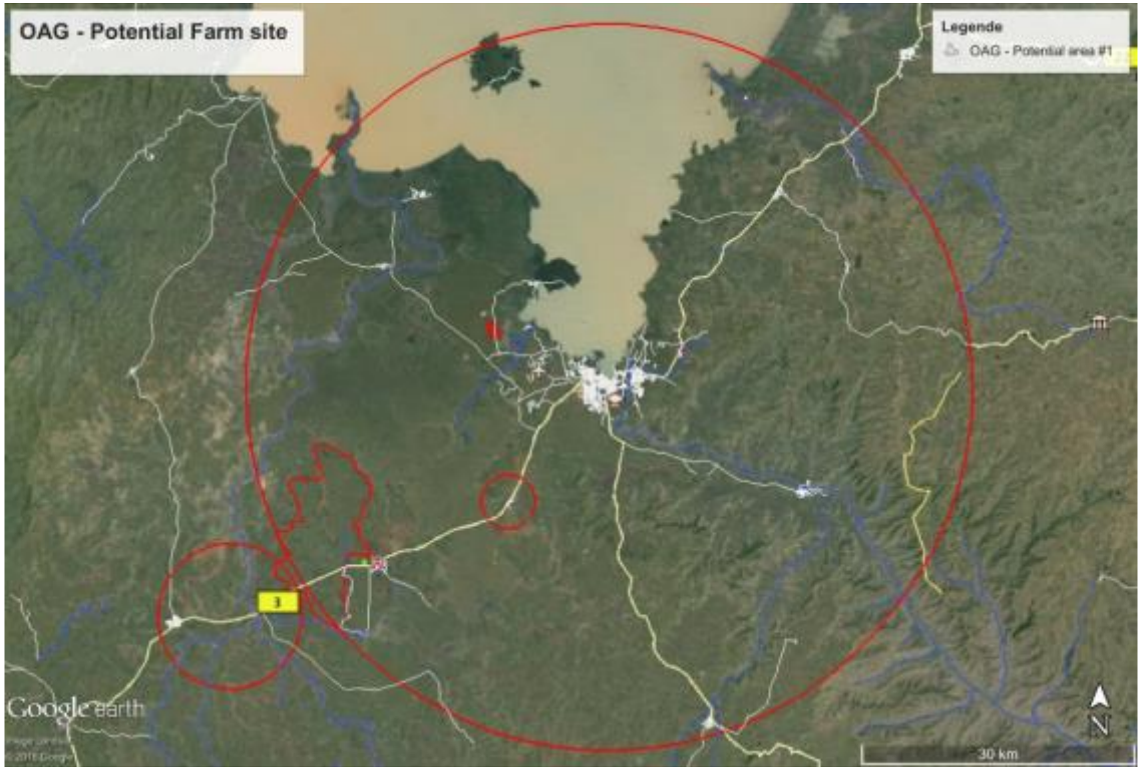


Figure 9: Potential Farm Sites (marked in small red circle; 40km radius of Bahir Dar = big red circle)

6.2.1.1.3 3rd Workshop

The **third meeting** started with an update about the administrative progress of the project. At the time of the meeting a dedicated group – including the president of the university, the vice president of finances and research and the dean of the agricultural department – has decided to implement a model farm for organic practices. This includes the official formation of the OAG concerning the ToRs.

Table 33: Economic In- and Output Table

		INPUT (Birr/kg)	**SALES (Birr/kg)**
Crop		Seeds	Yield
Cash Crops / HH - use	Maize	18	5
	Potatoes	30	5,5
	Wheat	8	8
	sorghum	11	11
	Teff	12	15
Legumes	Vicia hirsuta	20	0
	Faba beans	10	11
	Lupine	50	0
	Nug	12	20
	Alfalfa	40	0
	Chickpea	12	13
	Beans	11	11

The main topic of the third meeting has been the discussion about a crop rotation and crop prices on local market level. With the argumentation of organic food as a momentum of increase of production the products will also be sold at the market and no special organic pricing will be applied. This means that the argumentation for organic production is not sourced in its higher market value but in an increase of production per area (as described in…).

A crop rotation has been suggested by the facilitator which has been developed with organic and local experts (as explained in chapter *Crop Rotation*). The crop rotation has been revised by the OAG and small adaptions have been made concerning the varieties.

Table 34: Crop rotation (after adjustments according to the OAG)

YEAR	**INPUT**	**OUTPUT**

Plot Number	Crop	JUN	NOV	seeds kg/ha	% Seeds bought	Sold
1	Alfalfa		X	10	0%	0%
	Alfalfa			0	0%	0%
2	Alfalfa			0	0%	0%
	Alfalfa			0	0%	0%
3	Maize		X	27,5	0%	100%
	Faba beans	X		150	10%	90%
4	Potatoes		X	2000	10%	90%
	Teff	X		9	10%	100%
5	Lupine		X	75	10%	0%
	Nug	X		12	10%	100%
6	Wheat		X	125	10%	100%
	Chickpea	X		100	10%	100%
7	Teff		X	10	10%	100%
	Sorghum	X		12	10%	100%
8	Beans		X	150	10%	100%
	Nug	X		12	10%	100%

Interesting to recognize out of the organic perspective is that key crops like lupine and alfalfa are free to purchase from the local research center ARARI. The oil producing crop nug is the most expensive and hard to process crop. On the local market it is possible to get the needed varieties for the crop rotation.

6.2.1.1.4 4th Workshop

The last meeting of the OAG is meant to evaluate the planning instrument developed in the last 3 months. The functionalities will be tested and possible improvements are meant to be identified within a participatory process.

Planning of the Meeting. The first precondition was to develop the planning instrument so far that all necessary parts are integrated concerning to the organic principles. This includes the subjects of:

- Crops and crop rotation
- Natural Fencing

- General land use distribution
- Infrastructures
- Nutrient balances for the FIELD, STABLE & FARMGATE
- Economic models for several out & inputs
- Apiculture
- Water harvesting
- Crop water requirements
- Water balance & Irrigation needs
- Gross margin
- Total financial plan

The aim of the evaluation meeting is the generation of the local expert perspective. Therefore, a participatory approach has been chosen. The participants have knowledge about specific fields in agricultural context, so that it can be concluded that there is some knowledge about the principles of a farm. The aim was to reduce the input from facilitation site and to increase the active contribution of the participants. To reach this aim the first step was to engage the participants in the exchange. In the following the schedule will be described in detail:

1. Introduction
2. Brainstorm
3. Demonstration
4. What to do how
5. Follow up

Introduction. In the introduction, every participant and the facilitator introduced themselves with their name, organization and which experiences he/she has. Furthermore, the project responsible Bernhard Freyer introduced the latest news to the OAG. New in this meeting was Dr. Menal Wondie who will take over the local responsibility in a combination of ARARI and Bahir Dar University. It has been presented that he will take over the responsibility for the future meetings of the OAG and their topics to discuss.

Brainstorm. After the introduction, the participants were asked to pair up and to brainstorm about the different issues that need to integrate in such a tool along the subjects of Crops & Rotation, Nutrients, Water, Animal Husbandry & Economics. Additionally, they were asked to add any subject that might be missing what brought up the subject of social which is closely linked to the economics. The new subject economics & social replaced the economics. The participants had 7 minutes for each subject to brainstorm. After this the topic rotated for each pair till every pair had contributed their inputs to each subject – these additions have been marked with a red color (see Annex).

After the brainstorming, each participant presented one of the subjects to level the information transfer. Through this brainstorming session, the scope of the participants could be shared and additionally enlarged at the same time concerning the complexity of such a planning process. The results can be found in the following.

Demonstration. In this part of the meeting the instrument and its functionalities have been explained in detail and based on the EXCEL-Sheet presented. After the discussion, there has been a discussion about the different subsystems and what might be adapted and integrated as well (see chapter results).

What to do how. In this part of the meeting the participants were asked to develop a setting for the farmers how they could use the planning instrument and under what circumstances this could reach the effect it is made for. Therefore, the participants pair up and collected their ideas. Later on the concepts have been exchanged and the together the optimal circumstances and setting concerning to the opinion of the experts has been defined.

Follow up. In the follow up part the participants under the guiding of the facilitator decided on a way how the OAG will continue without Max Manderscheid.

Results. In the following the detailed description about the outcomes will give more clarity about the ideas and perceptions of the important issues of a model. The sections will be described together to give a broader picture and point out the relations and linkages.

In the brainstorm session the following data have been generated according to the participatory framework described in the *planning of the meeting*.

Table 35: Outcome Workshop

Water	Animal Husbandry
- Water resource assessment study (rainwater, surface water, underground water) - Water requirement/demand on farm - Analyse the gap (water harvesting) - Seek for the gap (if any) - Apply different water conservation technologies (water harvesting, deep well, diversion) - Conclude crop/lifestock water vegetation for detail planning - Water management	- Fishery with machinery water harvesting structures - Small ruminants like sheep - Chickens (within the yard) - Plant residues and crop seeds (silage?) - Chicken organic matter in the yard - Storage for eggs - House construction for chicken & sheep - Goats - Fattening - Milk processing - Beer

- Water harvesting (rainwater & runoff) - Drip irrigation - Small dams - Sprinkler	- Artificial insemination service - Cows/dariy equipement - Starch &protein feed - Stable unit & pasture - Slurry storage - Fodder for two seasons - Correct waster mgmt
Nutrients	Economics & Social
- Nutrient cycles closed system (OM cycle) - Legume crops (alfalfa…, alleys) - Green manuring, compost(cover crop) - Farm yard manure – zerograssed - Slurry tank - Biogas - Compost site; techniques of composting - Transportation of slurry & compost - Pasture management (white clover) - Fodder trees - High biomass producing species - Crop rotation & intercropping - Integration of trees/shrubs with physical soil / water conservation - Mulching - Lime/pH - P rockphsophat - P- uptaking plants e.g. lupine	- Market value of products (market oriented - Labour productivity - Value chain - The economics of land (land value) - Socially valuable and demand driven products - Profit (maximization) – but optimization - Demonstration & popularization of technologies - Sustainability - Scaling up – in terms of innovation (R&O) & specialization - Economics of the environment (natural resource economics) - Asthatet value of the farm/project - Fair prices - Different market strategies - Consumer analysis - Full cost calculations

- Fertilizer trees - Manure (animal) management - Effect of mulching on pests	- Assessment of the N in the food legumes - Labour balance - Training of the labourers
Crop & Rotation	

- Plants (crops, shrubs, tree, grasses)
- Annual crops:
  ○ Cereals
  ○ Legumes
  ○ Root & tubers
  ○ Vegetables
  ○ Napier grass
  ○ Spices/ medicines
- Shrubs
  ○ Hedges
  ○ Alley
  ○ Cooking
- Trees
  ○ Fruits
  ○ Agroforestry
  ○ Timber – for house construction
- Grasses
  ○ Conservation purposes
  ○ Feed & fodder
- Pasture: White clover/grass
- Medicinal & aromatic plants
- Essential oilplants
- Rotation
  ○ Should consider spp. Variants	

o Should consider reet depth & growth habot o Should consider diseases and pest o NC Balance o Ley farming - Integrated pest mgmt. - Storage & processing

Comparing these criteria of the workshop that should be integrated in the instrument with the existing instrument showed that there are mostly all engineering and natural-scientific aspects integrated. Still there is missing a part that shows the procedural implementation with the social and political external variables. Therefore, the third part of the workshop was about to be guidance in a certain sense.

To define a certain possible pathway gives indication about the actions that need to be undertaken fulfilling the realization of the project. In that manner it is of critical importance to integrate an insider perspective to ensure local knowledge about certain issues concerning administrative work and extension work itself. In pairs the participants have been designing pathways for a successful implementation of the project taking several criteria into account. A summary of these findings can be found below:

Table 36: Possible pathways for challenges seen by OAG

Group #1	Group #2
1) Developing detail operational manual for each topic component 2) Establishing demonstration sire for on-job training 3) Documentation about everything - Experience - Failure - Success 4) Revising the tools (remaking the gaps)	1) Demonstration & trainings 2) Field observations 3) Participations → model farmers 4) Follow up and making the extension packages & the farm model 5) Strong linkages in Kebele – Woreda – Zone levels (monitoring & evaluation)

5) Refining the approaches with the active investment of the stakeholder (farmer) 6) THINGS TO BE INCLUDED - Revising the tool with the actual site - Considering the social components to devise better strategy to scale up	

In reflection with the group the pathway for the realization has been analyzed and both suggestions ended in a package that has to be created. The package is well known in the areas where extension works has been done. It is basically a manual for farmers to continue their work when they have been trained and the aim is to continue the support preventing the switch back to old patterns/practices. This approach has been concluded on being very top-down and lacking the local knowledge and interest. Concluding that in the base line survey the interest and knowledge of the participating farmers need to be integrated and based on this an overall model can be generated. Critical issues are the integration of the training on different political levels. Therefore, it has to be ensured that certain information is distributed to the important stakeholder at these different levels.

6.2.1.1.5 Model Farm and its Organization

Concerning the overall analysis and the comparison and counterchecking of the farms' performance that is ensured through several measures. Continuous research, a farm report and the guidance and overall responsibility of the European farmer give indication and insurance about the performance of the farm and its planning instrument. The participants mentioned a

6.2.2 Gender

In the following the results of the workshop on gender topics are explained. First the general observations out of the participatory observations are described to better explain the context and the situation of the workshop. These include observations about how participants interacted and group dynamics developed throughout the workshop e.g. the difference of cooperating in a workshop of women and men. The following results are based on the workshop contributions. The three sections *Household, Agriculture, Economics & Market* entail the outcomes of the workshop. The described general situation according to each of the topics has been tackled by certain innovations. Some of the overall challenges concerning gender are general equality between women and men, but also the question of equality on the countryside and in urban areas (e.g. education).

6.2.2.1 Observations

A general observation of this research concerning gender is the difference of women cooperation compared with men cooperation. The women in the workshop tried more to develop the outcome together. A higher interaction between the participants has been observed while trying to fill in the sheet compared with the organic advisory group which is male dominated. The problem is more in focus than the interactional hierarchies. Additionally, it could be observed that in the gender group, once the discussion is engaged, the participants are interactively discussing the topics that are triggered by the facilitators but additionally find topics related and integrate them.

Reflecting on the workability of the groups formed and engaged in the planning process, it has to be stated that the matter of success of the group can also be the facilitators issue. The facilitator is responsible for the engagement of the participants. That way the adaption to the groups circumstances is the responsibility of the facilitator.

The tables below have been created during the first workshop. The participants were divided in groups of two to three people and were meant to work on each topic for 15 minutes and then continue with the next topic. The topics were household, agriculture and economy/market. In the flow of the workshop this particular schedule needed to be adapted. The groups were working on the topics as long as they felt that the discussion was necessary. The different groups all ended in engaged debates about each topic. The outcome was a more compressed and mainstreamed opinion of the whole group concerning gender in agriculture and the hidden challenges in a potential change of the inequitable patterns. For each single subjects , the major challenges and pathways are explained below.

6.2.2.2 Household

Regarding gender equality in the household (HH) of Ethiopian farmers, the workshop led to several conclusions. The most deal with the pathways out of inequity that could directly be influenced by a model farm and the demonstration of alternating practices. Through those female farmers' perception is changing and the realization of that change on HH-level has less hurdles. The general assumptions defined the surrounding of the HH as the territory in which women are responsible, take major decisions and are in charge for several things. The nutrition of the family depends on the activity of the women in the kitchen gardens and the general cultivation of fruits and vegetables for the home consumption. Most of the HH have very poor infrastructures. There is mostly a lack of electricity and water, what puts additional workloads on the women since they are not able to invest in technologies that would help them for domestic labor and water supply.

There are other inequities that have different social origins. These are based in social traditions carried through the decades and through this established as socially accepted. According to the participants, women in rural areas have less rights concerning important community decisions and contribution to the community. Another important social factor is the development of an educated societal fraction in rural areas that is also dominated by men. The population of rural areas tend to aim a higher education to have better chances of employment. This trend as such is not negative but the fact that for men it is easier to make that step because they are not as embedded on the HH-level turns the trend to a male dominated phenomenon. These structures lead to a higher workload for women in total because they tend to work as much on the field as their male partners. The addition of HH-tasks and agricultural creates a workload for women that goes far beyond those of the men.

The discussion about how the modelling of a farm can calculate and improve these issues brought up some innovative ideas that would support the women in daily life and awareness. According to the participants, this awareness is also necessary to be achieved by the women themselves. Often, women are used to the traditional role on HH-level so that they do not question any the patterns they are used to. The participants of the gender group identified some important innovations that could be integrated in a model farm to encounter gender inequity on a basic level. The integration of a basic infrastructure has the potential to drastically change the HH-circumstances and reduces the daily challenges like water and electricity supply. Investments like washing machines, cooking machinery – like electric or gas oven – can easily reduce the workload of women. For these innovations another kind of technical support would be needed. The governments' or extension work in general needs to be changed since it has to be adapted to the new technologies that would then be implemented. Another useful support tackles hygienic issues to ensure the family' health.

Table 37: Gender on HH level – general situation

	General situation	Innovation
HH	• Urban women more educated • rural women unequal rights and cultural hindrance • hand tools for vegetable production • providing fruits, vegetables (health care, nutrient balances) • tubers and low input vegetable production in the urban areas • promoting electricity, water, technology would free the women 90%HH activities • infrastructural development • awareness creation division of labor /HH	• laundry, washing machine • baking, cooking machinery • water supply water harvesting • biogas, solar energy • septic tank • technical assistance lower level extension workers

6.2.2.3 Agriculture

According to the participants, women are as sophisticated in agricultural practices as men, but the major difference is that the women rarely get the same credits for their work. The knowledge about agricultural practices is at least 50% in the HH. Men tend to create the image that women are less able to do good agricultural practices to diminish the women's' role. Women are motivated in agricultural trainings and to learn new methods and practices but the socio-cultural practices often decrease their innovative actions since it is not common to act differently than the neighbors do. This practice is found in the most rural areas. Women would face at least two major social hurdles when acting (I) against the traditional schedule and (II) against the practices implemented by men.

The awareness of soil fertility as a major constraint for agricultural productivity is very present but mostly the lack of time and knowledge reduce the actions regarding this topic. The correlation between the practices of female farmers and farmers in general and their income are closely linked. 80% of Ethiopians' farmers are smallholder and practices agricultural for subsistence reasons. Additionally, a high percentage of those smallholder farmers is poor (…). Female headed farms tend to be focused more on the nutrition of the family. According to the participants of the gender group, an increasing trend is the tendency that farmers believe in the highly manipulated fertilizers that are distributed by associations and governmental institutions. The search for an answer to the decreasing productivity is not an option for all agricultural problems and often accelerates soil degradation. This described lack of income forces many female headed farms to use traditional fertilization methods – like composting, green manuring and others. From an organic farming perspective, this is not a bad thing since farmers are then familiar with topics like compost and manuring. But it is essential that the perception of these farmers is linked to a positive connotation. A farmer not using chemical pesticides of fertilizers is perceived as poor and not part of the community. Pesticides and fertilizers seem to have evolved to a status symbol in community realtions.

The model farm has therefore the chance to create awareness with valuing traditional practices positively. In potential workshops given at the farm the focus on practices like green manuring and composting can easily be pointed out to be traditional practices. And clearly stating their positive effects on soil and nutrition of the crops. Linking those practices to the only members – the female farmers – of the farmer society has crucial impact on the perception and awareness. Another low barrier for the improvement of women in agricultural practices is the introduction of technical advisory which is given to men and women equally. Also the training and education for women to become extension workers needs improvement since only 2% of the extension workers are female. That way, the whole social phenomenon of women perception in the society is challenged. Concerning the traditional practices, women have an advantage in the training and facilitation for proper composting practices.

Special attention regarding the environmental circumstances needs to be given to the degradation of land. Due to the socially lower status, the farm land of women is often located at marginal sites and needs more attention concerning land and water management. Another matter of education concerns the different potential adaptions to enhance the stability of production on field level. Detailed information about the potential of agricultural productivity is gathered in the chapter …Since women are less educated and are participating less in workshops, their diversity or flexibility to adapt to differing environmental circumstances and challenges is lower. This can be tackled with gender balanced workshops and a different set of extension work. Workshops concerning for example the adaption to climate change and other institutionalized workshops need to include the women. The variety of methods taught increase the knowledge of the participants. That way it is easier for them to improvise with their daily field practice when realize a certain change in the environmental circumstances.

Mostly the income for women headed farms is more crucial and to be liquid has a higher rank. Women tend to sell their products as soon as possible and have not the option to store because of the actual liquidity. Due to that fact they have weaker arguments in bargaining since they need to money more urgently. This fact forces them to go into contract with worse conditions than their male concurrence. The participants of the workshop also named the sexual criminality a reason why women get suppressed in a competition with male farmers.

Table 38: Gender in agricultural context

	General situation	Innovation
Agriculture	• 50% women knowledge on agriculture • enhance the soil • women not scared • awareness creation on land use □ enhancing the production • socio-cultural practices • motivation increase • customized problems are minimized • less income, less mineral fertilizer • they need to use traditional fertilizer • tractor • harvester	• technical advisory 70:30 (men:women) • female extension workers (2% female) • female at whole not only HH • women do the composting □ training and facilitation of proper composting practices • women headed HHs are located at the marginal land □ erosion takes place easily • difference in productivity □ educational gap • -women use more traditional seeds • -time constraint in selling the products
	□women sell their products as soon as possible to increase their income and actual liquidity □weaker in bargaining since the money is needed more urgently □need of selling forces them to sell at any circumstances □ sexual criminality at the market	

6.2.2.4 Economics & Market

Within this section the participants of the workshop decided to have a more open discussion. The discussion about economics and market has not been divided in the sections of general information and innovation but tended to be a more clustered discussion. This discussion was more reasonable to be held in an open setting. That means a setting where no structure is predefined and participants decide on the topics and methods to talk about those.

The major issues about the economics and the market dealt with education since most of the female farmers are undereducated and are not able to properly calculate and bargain. Their focus is to increase the direct income and not to sell for lower prices. With this stable and more refunding sales female farmers are able to invest in small tools that might prevent health problems and increase the productivity. Health problems often occur when young mothers work hard on the fields. Small tools like a *Handrechen etc.* can increase the time efficiency on daily work on the field.

A major challenge women are facing in the concern of income is the criminality and its risks. Female farmers that want to sell their products on the local market need to use the same market conditions than men. This mostly includes walks of several hours through the nights. This makes women very vulnerable in those situations. Women refuse to go to the market at these times. That way women in the majority get worse spots for selling their products and have less opportunities to sell at a good price and quantity. The need for an institutional support that tackles those insecurities is of tremendous importance. Meanwhile the model farm can take over awareness creation in the concerns of educating farmers in the installment of a farm shop.

Table 39: Gender in economics &market

	General situation & Innovation
Economics/ Market	• Teaching society • awareness/ training • organization for women (credibility, advisory 6 sowing groups) • selling their veg./plants, by small tools • produce variety to the market family nutrition • increase the women strength at market level • seed material for female production engaging seed supply • women market place (clear rules & regulations), (hygienic security)

These women associations like named above are tremendously having influence on the female farmers' potential and strength on market level. Since the female farmers till now use very traditional and limited varieties of seed material the increase of seed exchange in these organizations can help farmers to cope with different environmental challenges by adapting their seed material. Within these associations it is possible to increase the social pressure on governmental institutions to establish women market places where strict rules and regulations can help preventing to give more advantage to male farmers, criminality and where clear distribution rules make life easier for selling women.

6.2.2.5 Conclusion for development

Reflecting the workshop with the gender group concerning its implication for the practice of the whole sector and theory it shows how theory and practice divert. The theory of gender consideration in development work and in particular in project planning, implementation and evaluation shows discrepancies with its realization. The women integrated in this project were not having any experience working with such project. Additionally, participants mentioned that even if there is research which integrates female farmers the dissemination process of outcomes is rather bad. Women might be part of a research in the sense that they are contributing to the data collection but in only a few cases female farmers have a real advantage of joining the research. That creates the base for an argumentation pro inclusion of a gender perspective from the beginning (planning) to the end (evaluation).

Actual literature argues that women are meant to be included in the right setting. Through the research it could be stated that the choice of the setting might be one of the most important topics regarding the differences of culture. In the Ethiopian culture a strong hierarchy – going from down from rich to poor and from down from men to women – tends to neglect the parts of the society that are poor and powerless. In Ethiopia smallholder farmer have less influence on power issues but still are a huge part of the society. Since these smallholder farmers are of high importance for the whole agricultural sector it is important to include these perspectives. But therefore, the setting needs to be chosen wise. A setting where women are supposed to interact with the men is not the right setting to get the first insights for these perspective. Women who are supposed to speak out freely should not be encountered bot be encountered by hierarchically higher status men. The statements probably would be different and the core messages could not be transported. Therefore, it is important – even in an university surrounding – to engage a discourse where women feel comfortable and are able to just state their issues and express their opinion. To also touch the critical topics it is important to create a safe space for women to not be judged when exchanging their opinions. The observation of this research underlines the importance of a safe space for the protected exchange of information and also the mentioning of critical topics.

Interesting to mention are also the group dynamics within the gender group compared to the men dominated Organic Advisory Group. The gender group was more interactive and discussion were fluently and engaged. Two hypothesis are stated regarding this research:

1. For the exchange of information and the naming of critical issues is strongly depending on the setting and how protected the selected participants feel.
2. A topic that involves the personality and identity of the participants gets more active and engage involvement in the participation.

The workshop for the gender group showed how much cultural embeddedness is causing gender related inequity. The major challenge for women in the agricultural sector and the gender equity is based in the social and traditional structures of Ethiopia. Concerning the development or implementation of new techniques or practices it is challenging to deal with the dominating and prevailing structures. The potential change in cultural or social structures only can be triggered by convincing the participating parties. This process of convincing is not meant to trigger any economic advantages but to embed an understanding of the subject within the parties. Concerning the gender consideration an advantage for the male parties has to be pointed out to make male parties willing to join the project.

6.3 Motivation

6.3.1 General

In the following the different motivations of the participants of the groups and the experts are discussed. In the following the outcomes based on the workshops and participatory observation concerning the motivation are explained.

6.3.2 OAG

First the OAG is analyzed about its motivation and key factors will be discussed going beyond the description in *2nd Workshop.* In the workshop the task has been to reflect on the individual answers – as described in *Participatory Modelling* – the question of:

1. What is my motivation to join the OAG on all levels (including professional as well as individual reasons)?
2. Which expectation do I have during this modelling process (personal)?
3. What do I see as challenging concerning the participatory modelling process?

This reflection has been communicated to not be judged and is to be shared voluntarily. Since all participants agreed to share the ideas and thoughts a fruitful discussion could be enhanced. In ***Error! Reference source not found.*** a overview is provided. Through the participatory observation it could observed that in first instance some participants were hesitating to share their thoughts. Through the intimate setting of the group with five participants the hesitating participants gained confidence. Additionally, through the openness of other participants the setting for an open discussion was offered since the arguments of the “first sharing participants” gave room for discussion. During the discussion of the shared thoughts all participants shared their thoughts and reflection on the three topics. Together with participants the table below could be formed.

A crucial observation for the motivation is that there are mainly two categories of motivations. The first category is based on the professional thoughts. Participants are aiming to achieve a bundle of advantages for the university and the Ethiopian agricultural sector. Interesting in this category is the mentioning of agricultural dependency. Since the group consisting of PhD-students and young professionals has not have any courses on organic farming the perception of organic farming as a pathway to consist and support the Ethiopian agriculture shows a broad awareness within the group. Strongly linked to Ethiopia’s’ dependency on agriculture is the argument of an increase in productivity per hectare through a cultivated diversity. This point raised by more than one participant shows a sensitivity for the topics of conventional farming promoted mono-cultures. More scientifically the group showed motivation the understanding of different sub-sections and their understanding in organic farming. These driving forces are called in the following the scientific specializations. These scientific specializations include motivations ranging from holistic understanding of organic farming as a measure to cope with climate change or the reduction of natural resource pollution through organic farming till the way of increasing organic matter on farm level or soil fertility. These are very detailed and specific motivations on a scientific level.

The interesting part of the motivation – the personal motivation – is only tackled by very few participants. These include the learning about the organic farming principles in theory and in practice as a main interest and motivation. The personal motivation – out of the exercise – can be summarized in the learning of an interdisciplinary exchange.

This is linked closely to the expectations of the participants since the last point of the motivation implies a learning setting. Generally, the part of the expectations concerning the OAG itself has been harder to trigger with the participants since it has been expected that the facilitator is having expectations and would want to use more extractive methods. Therefore, it has been essential to explain the approach and the mindset of the facilitator and the whole study in advance. With this explanation as background the participants were able to formulate certain expectations. The expectations of knowledge transfer and practice have been mentioned by all participants and form thereby the strongest consideration in the continuing participatory modelling. An interesting observation is the fact that the participants all mentioned expectations that go beyond the participatory modelling – even though this has been stated several times. A possible conclusion out of this is that the participants unconsciously or consciously perceive the topic of organic farming and understand themselves as group timely not bound to the field work of the researcher. Additionally, the participants have understood that organic farming as such is nothing to be implemented on a short-term scale. Nevertheless, the expectations of the participants have been beyond the scope of this study but showed an engagement of the young scientists in an early stage of the modelling process – second workshop. In the discussion with the participants about what might be possible in the timely compromised frame of this research all participants agreed on the statement that in the time of the field work of the facilitator/researcher it is important to set the first steps for such a long-term implementation. The expectation of a sketch of an organic model farm to be able to further plan and implement the farm after the research left again is the outcome of the discussion about potential goals of the OAG.

The challenges that were identified by the participants have one thing in common what seems to be a main hurdle in the realization of projects like an organic model farm. It is the administration of either the university or the government (land distribution). In the first meeting the participants were reluctant on the acknowledgement of the OAG on university level. Since this could be clarified with the dean and ToRs (see Annex:

Terms of Reference OAG) could be settled the participants were more engaged in the whole process. This could be seen in the reaction to mails and the settling of new workshop dates. When there had been less interaction before concerning the workshops the participants seemed to be interested after the official acknowledgement. This fact gives an impression on the manner how things work in the university system of Bahir Dar. The participants concerns show the possible struggles in the implementation process of a model farm. This sensibility for the administrative hurdles let the participants doubt about the overall usefulness of this group. The discussion about potential pathways and the approach that would have been favored by them showed that for a planning and a real implementation of a model farm the locals would have gone first through the administrative procedures instead of starting the planning and the administration at the same time. Within this discussion, the facilitator switched to the role of the researcher to better give insights about the study and its aims. The explanation that the participatory modelling process is on the one hand part of a realistic attempt to setup a model farm but on the other – and more important – the process is to foster organic farming in an disciplinary exchange and ensure the knowledge exchange between all different parties.

Another challenge – unanimous – of the young researchers has been the financial activities. Since this seemed to be an important issue the facilitator decided to integrate it in the workshop and go beyond this challenge and get to know its roots and potentials. It showed that the participants have the perception of this group to be more effective if there could be paid employment. Through this important issue it has been clarified that the invests of time and labor for the contribution to the OAG are limited from the side of the participants.

Table 40: Motivation, expectation, challenges – reflection of participants

	Motivation	Expectations	Challenges
Professional Level	• ET economic dependency on agriculture • Scientific reasons • Increase productivity through diversity • OF as strategy to cope with CC • Learn about the OF principles • Sustainability of farming→OM increase • Dependency of artificial products • Soil fertility • Pollution reduction • Integration of aquatic systems • Alternatives for chemical farming	• Need to see organic farming practices • Replication of good practices • Modern organic farming design **implementation as mentor** • Smallholder application • Knowledge • Practice • Knowledge transfer concerning the different organic farming issues	• The identification of suitable land • Administrative dalliances • Financial activities • Land identification and administration

6.3.3 Gender

The gender group has been formed through the key informant Dr. Mulunesh. As key informant, she provided the contacts to potentially interested participants as described in *Gender.* Through this the gender group consists of different disciplines that are represented by females.

The first workshop with the group had the topic of potential innovations and pathways to cope with gender related inequalities on three different levels – agriculture, HH, economics & market. In a first reflection round about the topic gender in general and in the introduction round it became clear that all participants have some sort of experienced inequality concerning gender. This ranged from dramatic differences between the treatment of women and men in the educational sector to self-experienced gender inequality in the families. Three of the participants are conducting their PhDs in the overlapping field of gender in agriculture. Others' awareness of the topic is generated through experiences in their livelihood.

Through all these different backgrounds the participants of the gender group have a common goal. This is to integrate gender equality and equity in a safe surrounding like a model farm. Through this they see the opportunity to integrate gender in the structural and management level of a farm to showcase another way of dealing with gender on farm level. The gender group provides a frame where all potential situation and solution can be expressed without judgement.

There are different motivational factors that come into play with the different participants. First the acknowledgement of gender in a scientific process is motivating the participants unanimous. The discussion about potential innovations that are feasible to be integrated in the model farm creates an explorative setting. Within this setting there is space and acknowledgement of gender related topics. This fact of acknowledging the gender position motivates the participants. During the first workshop a certain enthusiasm has grown since participants were able to exchange ideas in an open setting. This shows the importance of the right setting for sensible topics. An open and safe setting gives the opportunity to engage participants and trigger the exchange of knowledge, expertise and experience.

6.3.4 Experts

Concerning the contribution of experts, a crucial element has been the scientific and expert network. This has been created through networking with different scientists and was enlarged by a contacting different institutions. The motivation of those experts concerning their contribution was mainly the will to help create a tool for modelling. Additionally, the experts saw it in their scope of responsibility to contribute their knowledge to enable others to understand the underlying principles and the facts. The integration of the expert knowledge is an important factor. This has been agreed on with every expert but for most of the experts a contribution in a more integrated approach has not been possible due to different reasons e.g. time.

7 DISCUSSION

The discussion of this study is divided in five sub-sections: First, it will address the overall research question; second, the findings of this study concerning the communication will be discussed; the third section addresses the topic of the model creation itself; fourth, the motivational perspectives and issues concerning the long-term integration of participants will be discussed; and finally, the actual practical and theoretical implications and for future research and next logical steps conclude this section. In all sections the discussion is about to give insights about the findings and the relation to the broader picture of previous findings and the state of the art. Additionally, new insights concerning methods and interpretation are included regarding each sub-section.

7.1 Application of study to research question

In this study we have addressed the following research question: how can organic farming be fostered in order to engage inter- and transdisciplinary research and teaching in the case of Amhara Region, Ethiopia? In order to discuss the results of the study in regards of how far the question has been answered the results have to be reflected. This reflection not only includes the results of this particular study but also past research, which allows us to understand the study's contribution and impact to its field.

Through this study's participatory modelling process and the actual development of the model, organic farming has become more popular in the Amhara region as well as understood on a scientific level. This scientific level includes the participating researchers and teachers whom are meant to function as multipliers. These multipliers have the possibility to increase attention given to organic farming on a broader level such as at educational institutions. Within the Amhara region, these institutions are limited in number, however the BDU is the largest institution focusing on this type of research.

This research has encouraged the exchange between different disciplines and fields through the creation of the joint model. The model creation has brought together different researchers of different disciplines as well as gender oriented researchers and teachers. The joint development of an organic model farm led to the diffusion of certain disciplinary views on the topic. The participants got went through the process of planning the different subsystems of an organic farm and contributed even though their expertise has been in different subject. To have one participants with expertise in the certain field modelled was a prerequisite for the learning process of the other participants. The result of a model concerning farm system modelling criteria engaged the discussion about topics from social innovations to natural components. Out of the trials of the model and the arising discourses out of it the awareness of certain interlinked topics in organic farming could be raised in the participants group. The realization of the benefits of the inter- and transdisciplinarity carries the potential of acknowledging and using inter- and transdisciplinary approaches in future research.

An interesting observation throughout the study is that there has been an interrelationship between organic farming and the inter- and transdisciplinary perspectives. Organic farming, understood as a system, implies the integration of several disciplines from a scientific perspective. Beside following the principles of organic farming, bringing those different views together and enhance the interaction and exchanges between the different disciplines and fields makes a farming system organic. Only the certain cooperation can assure the added-value that organic farming implies. The other part is that through an inter- and transdisciplinary approach organic farming is brought to the focus since this kind of agricultural practice allows disciplines and fields to cross each other's borders and exchange and analyze the influences. This counts especially for the field of research and teaching in the Ethiopian context which show more traditional patterns. These patterns make group works and discussions an exception and more widely spoken the inter- and transdisciplinary exchange a rarity. Instead disciplinary specification is common and the deepening of disciplinary knowledge is acknowledged and valued. Additionally, research and teaching are mainly excluding outside perspectives of other fields of expertise and profession. Since organic farming requires both, a certain level of disciplinary profundity and the inter- and transdisciplinary exchange, it tackles on one hand the disciplinary cooperation and the integration of other fields of expertise. On the other hand, through this approach organic farming as such is strengthened in the research and teaching discourse.

To enable the communication of inter- and transdisciplinary stakeholders this study showed participatory modelling as one option to foster the exchange of knowledge. This integration of participants and stakeholders in a co-creative process where all contributions are valued entails the exchange between the participants. Since the inter- and transdisciplinary communication between the stakeholders is perceived and has been observed as engaged and rich discussion organic farming can be stated as fostered. In detail this will be discussed in the following – *Communication.*

The model of organic farming itself helped to identify the different disciplines, fields and their specific elements – necessary to integrate in an organic farm – to understand and – with the model – simulate their key relations and interactions. This understanding helped to create a holistic picture of the on-farm processes between different sub-systems. The understanding of the participants' on-farm processes and organic farming as the vehicle to combine those interactions support the fostering of organic farming in an inter- and transdisciplinary discourse. This process of the model creation is discussed in the following sub-chapter – *The Model Itself.*

The study further analyzed the motivational reasons of the participants to be part of the research to better enable a long-term integration. The study itself shows a diversity of reasons varying from personal and identity motivations as observed in the case of the integration of gender related perspectives – to professional motivations concerning the learning about other disciplines and organic farming principles in particular. Additionally, the method of participatory modelling gives the option to embed participants in early stages of the modelling process. Through this a closer link between the participants and the project itself is fostered. In detail this is discussed in the chapter – *Motivation.*

7.2 Communication

In this study, the objective was inter alia to *enable knowledge exchange between actors of different research disciplines and other practical experts from the field*. Considering organic farming as the baseline for the research done, it implies the contribution and the collaboration of different stakeholders/actors. To facilitate a communication between those identified actors participatory modelling has been chosen to form a frame around these different disciplines and fields. The hypothesis that communication is increasing through the usage of a participatory modelling (PM) process according to organic farming principles can be acknowledged. Through the PM the disciplines got interlinked and a frame for inter- and transdisciplinary exchange was created. In the beginning the involved stakeholders were insecure about the interaction with other disciplines and had difficulties to identify the advantages of such an intervention. For the stakeholders, it is not unusual to cooperate with other disciplines. The difference made through this study is that the level of cooperation is deeper and stakeholders are bound together through their voluntary involvement in the different workshops. The distinction between this traditional and the new way of interaction is that the participants of the workshops worked together on one and the same topic. There was no such thing as bringing in the particular expertise without further elaboration. This conceptual characteristic in general and specifically in this case of PM uses the workshop to form a platform for constructive exchange. Therefore, the size of the groups was of essential importance. Through the small groups the participants were more engaged and got a better feeling of recognition and appreciation concerning their contribution. This will be further elaborated in the later chapter *Motivation.*

Looking at the broader context of communication in the research and teaching sector regarding the agricultural debate in the Amhara region the PM approach is a novelty in the sense of engaging communication. Through PM stakeholders that have not been able to join or contribute to the actual debate in research and teaching about agricultural and organic practices are part of the inter- and transdisciplinary network. The participants and experts contributing to this study triggered and steered a communication among each other and created an understanding for the fields of each other. This is the way organic farming supports the exchange of knowledge and fosters a holistic understanding of farms. The method of participatory modelling has been applicable for this study while it has been adapted to the circumstances. Key elements for the adaptions to this case and to trigger the communication and exchange between participants are (1) the early involvement of all relevant actors and (2) continuous workshops throughout the modelling process. PM is a suitable method to deal with even socially influenced systems – e.g. farming systems. Controversially discussed in the literature it is important that the circumstances are enabling an exchange and a communication of the participants. This implies a sensibility for social dynamics on the side of the facilitator and the ability to create space for the all participants to contribute in a safe space. It has been helpful to deal with the different groups separately. The gender group was able to exchange their ideas in a setting where they felt safer without diminishing the contributions of the OAG. In that case the outcomes of the separated workshops were shared and discussed. Through this the exchange of knowledge is guaranteed even though the groups are not physically meeting. Concerning the interaction and contribution of the different groups there is still potential for improvement but in the situation of the fieldwork the separation of the groups has been the only solution to secure the space for an open communication.

7.3 The Model Itself

The model. The way the model is designed corresponds with the literatures' distinction between the different categories of farming systems simulation—e.g., Linear Programming (LP), System Dynamics (SD), Agent-based models (ABM) (Bartolini et al., 2007; Bertomeu & Giménez, 2006; Bonabeau, 2002; Danzig & Thapa, 1997; Fiala & Freyer, 2016; Fokkens & Puylaert, 1981; Wilton et al., 1974). As the model combines a selection of organic farming components its basic theoretical principles closely linked to systems thinking. For the modelling theory, this means a SD approach. Since the developed model excludes social interactions and decisions, the SD approach fits for this study but needs to partly integrate LP components. The model itself is meant to simulate interactions and developments of natural components—e.g., from stable and nutrition balances up to irrigation requirements of single crop varieties during the applied planting season. Even though the modelling approach integrates the local expertise of different disciplines it follows linear programming. This means the interactions included in the model are one dimensional linear feedback loops that are defined through certain numerical input data and follow non-differential equations. This rational combination of the two categories of simulation theory—linear programming and system dynamics—has its origin the factors described in the following. The organic farming principles support systems thinking in agricultural practices and education. As Fiala et al (2016) describe as the basic understanding for farming system out of an historical perspective is here finding its path to application. The organic farm as such is incorporating and differing from conventional farms in the means of system understanding which implies the interlinkages between certain natural components as explained in the chapter ***Systems Thinking**.* Farming system models have not focused on the simulation of organic farms till now rather than concentrating on the conventional and productivity-oriented sector. The state of the art of farming systems research (FSR) defines certain models that are useful to integrate in the farm planning process to prevent failures—e.g., in crop rotation (see ROTOR in ***Linear Programming***) (Bachinger & Zander, 2007). Even more highly developed simulation tools for farm level simulations like *CropSyst* do not offer the simulation of important interactions regarding the organic principles. E.g. *CropSyst* is able to calculate the vegetation period of any crop including the nutritional needs and water requirements. The outcome of the simulation is a day-based schedule about which nutrients are needed and how much water can be expected to be irrigated. This leads to certain amounts of advised fertilizer usage and a pump requirement for the cropping system. The missing link for an organic approach is the inclusion of other nutrient cycles of the farming system or the calculation of potentially stored irrigation water. In the organic simulation model the nutrient cycles of the fields are interlinked with those of the stable since the manure that is put on the field comes out of the stable. Additionally, a systemic understanding of the water cycle includes all water that is falling on the farm land and is hindered to infiltrate as a potential source for irrigation. Therefore, an organic model includes those types of interrelations and aims to picture a holistic view on the farm. Like that example, there are many missing key systemic understandings between the different subsystems in *CropSyst*, such as stable-field relations and crop rotation-fodder balance relations. Thus, the generated model in this study fulfills several purposes integrating new interlinkages in the modelling process. First, it serves as a basic tool for the planning of *organic* farms on a small-scale level including all necessary organic principles. The difference to other models or simulation tools is the holistic approach that has been chosen in this study: to generate a farming system model that is able to allow different model sub-systems influence each other. The main challenge with an approach like this is the level of detail within each component of the model. This level needs to be adapted according to the sub-system and how far the detailed information is needed to simulate the interactions with other components and the final objective needs to be considered. For this study, a very detailed level of simulation has been found necessary for the components of nutrient balances and water management. Nutrient balances on a farm-level simulation are crucial in organic farming for the calculation of the nutrient supply for crops and livestock. To analyze such balances individually implies the exclusion of important mutual influences.

A new understanding of models. According to the literature this analytical and numerical part of the study and the applied thinking matches with the definition of classical hard systems thinking (Arfini et al., 2016). Therefore, this study concurs with previous research and scientific literature. In the design of this research, according to participatory modelling (PM) methods, a social component plays a role. The inclusion of participants in the modelling process takes a social component into account, which is not covered by hard systems thinking. Even though system dynamics takes social decisions into account the model is typically created by a modeler without previous social interactions. Using participatory modelling with organic farming leads to the questioning of how system thinking is embedded in the process. In previous studies, participatory modelling has been attempted to fit into a system dynamics approach (Forrester, 1994). This explanation of SD allows space for social interventions during the model implementation. This study understood participatory modelling to be of a wider context bringing together different disciplines and fields in the development phases of the model. Therefore, it is important to adjust the understanding of the framework of system dynamics in this study. PM is a method that goes beyond the borders of classical systems thinking categories. Approaching hard systems as a theory behind a LP model implies the need to take a broader look at the research in order to expand such categories. In this research, soft systems thinking—usually seen as a complement to hard systems thinking—acquires a new position. Soft systems thinking is the underlying theory for the integration of this model in a social surrounding. Through soft systems thinking the application of a model, such as the one developed here, enables social acceptance and aims to assure a certain usability. Therefore, the approaches are not categorized as opposing but in alliance with each other. The hard systems have been of importance in the quantification of the farm simulation. Without these calculations, the acknowledgement of organic farming practices at the research and teaching level would be lacking. The combination of hard and soft systems thinking in this study poses questions concerning the necessity of the clear differentiation of these two concepts when covering both important elements—quantification and social access—of the study. Further it can be asked if the inclusion of both concepts in a study enhances the quality in terms of the chances of acknowledgement on stakeholder level. This is not discussed in this study apart from two key observations. First, during the PM process, one main advantage became apparent in the discussions with the participants: resilience. The modelling process had the advantage that several disciplines could come together and exchange ideas and doubts. Through this a resilient model has been created that is more likely to cope with challenging circumstances. The second main observation that enriches the quality of a model through the inclusion of hard and soft systems thinking are creative ideas about additional sources of income or subsistence. The participants shared ideas—such as using water storage as a fishpond–thus increasing the quality of the model.

Another level. This approach of using hard and soft systems together finds approval in the Ethiopian context where research and on-farm reality are very disconnected. The importance of quantifiable results plays a role when talking about production or investment justification at the research level. Since there is no scientifically acknowledged best practice of organic farming in the Amhara Region and research predominantly focuses on conventional agricultural practices to increase productivity, organic farming needs to start from scratch concerning the explanation and argumentation of its potential productivity. The model of this study can support decision making processes about agricultural practices. This fact-based argumentation tool assists the organic movement in pointing out the advantages of organic farming in a numerical manner that delivers the base for the consideration about agricultural decisions.

Up until now, there have been only a few studies in the field of agricultural integrating participant perspectives throughout the modelling process (Jones et al., 2009; Mendoza & Prabhu, 2006; van Eeten et al., 2002). Even though the method of PM entails three different stages – model development, parameterization and evaluation – the extent of the integration of participants can vary in every part. Due to the method – modelling the farm along the parameterization process – it is hard to define a clear boarder between model development and parameterization stage. The workshops of the parameterization in this case clearly had an impact on the ongoing model development. This approach mitigated potential differences between the modelers' and the participants' perception of the model at a later development stage. The model could be adapted while it was still in the development phase and the programming has not been finished. Through this approach, the extent of adaptions at the end of the modelling process were minimal and entailed mostly small changes e.g. changes of units according to local or international standards. This has been displayed by the evaluation of the model that underwent only minor changes in the final workshop. Brought to a broader context this entails a key factor for research and teaching projects. A project or study conducted with PM with integrated hard and soft systems thinking can support faster completion because of the constant feedback loops with the participants. The overall study might take longer but in a lot of cases the studies or projects face additional adjustment time to integrate in the specific surrounding, e.g. social acceptance, natural components, local economic conditions. This additional time can be overcome with the PM approach.

7.4 Motivation

In this study, two main groups have been formed to perform certain workshops accompanying the model development – the organic advisor group (OAG) and the gender group. The OAG, consisting of young researchers and practitioners, came together in workshops during the period in which the fieldwork took place. The gender group met two times at later stages of the model development phase due to difficulties of identifying the participants, as explained later in this chapter. As described in the relevant literature, the importance of the setting of the participatory groups is of high importance (Cornwall, 2006; Hickey & Mohan, 2004; Stiglitz, 2002; Voinov & Bousquet, 2010), in this study for the gender group as well as for the researchers group. To create a surrounding suitable for the group members to feel comfortable and willing to share and contribute, challenges most facilitators. In this study, the advantage was that the facilitator was approximately the same age which gave the young BDU researcher confidence to talk openly since the hierarchy at university level is mostly dominated by age and status. Regarding the status, the intervention to talk about motivation, expectations and concerns in the beginning of the OAG-workshops gave a clear picture that there is no difference between the researcher from BOKU and from BDU through visualizing that all participants – including the facilitator – have certain expectation and concerns. Through this the participants shared their thoughts and doubts which are crucial in a model development phase since through mentioning these the aspects could be revised and changed in the model development. Appreciating the groups and their contribution is a key element in the PM of this study. By valuing the contributions, the participants gain confidence to communicate more openly. An important point of discussion in this study is the appreciation of any thought. This study was conducted in cooperation with the BDU and initially it had not been clear how the model might look like. Through the contributions – negative (e.g. doubts concerning the applicability) and positive (e.g. new ideas about additional agricultural practices) – of participants in several workshops it has been possible to shape a model that is adapted to the local circumstances of the Amhara Region. The point that is made here is that any contribution and exchange with the participants is a benefit for the model and other participants.

Gender. Concerning the gender group an important observation is that the male researchers of the OAG had inhibitions to invite female counterparts to generate a wider mixing of the group regarding the transdisciplinarity. Nevertheless, all participants of the gender group have shown strong interest and motivation to join this participatory modelling process. All women contributed voluntarily and had no expectation of any external or professional incentive. In contrary to the OAG the organization of the group did not require any formal procedures but rather woke a euphoria to talk about the topic. The participants of the gender group have been invited through a key informant – Dr. Mulunesh. The hypothesis might be stated that the contribution to a topic that deals with parts of your values or identity concludes in higher levels of motivation. This clear difference tells two main messages. First, the inclusion of women or gender oriented people in research or development projects has low obstacles concerning the motivation of those included. Second, the level of motivation increases with the level of identity that is initiated by the topic. These two statements have been found comparing the individual motivations of the participants of the two groups. In the gender group it has been prominent that the participants came from different background and only one of the six participants had an agricultural background. All others were motivated by the topic and the possibility of the contribution to a research that entails a gender perspective. According to the participants this study has been a rare chance to contribute to mention general points of inequity concerning gender. The gender debate in the research context in Amhara region is active, but according to the participants it tends to be a more political debate that focuses on the urban areas. This political debate contents equal opportunity for boys and girls concerning education and child labor. Several initiatives and trainings tackle the education of rural women concerning their rights but still the rural areas show high percentages of gender inequity. This fact motivated most of the participants to join the study since they are convinced that a showcase of farming practices that integrate gender equal distribution of power and workload has the potential to open the doors to gender equality in agricultural practices. The key to the motivation of the participants is the deep connection with the topic that goes beyond professional interests. Each participant has been facing situations where gender inequality had personal influence on them – e.g. in the own HH or social constellations. The PM focuses on small innovations and pathways that might have crucial impact on the female side of rural practices. Out of the workshops some interventions could clearly be pointed out considering the workload in the HHs besides the agricultural practices. Mentioning the innovation of washing machines or water supply at HH-level shows the simplicity of intervention that can be set to intervene in the field of gender equity. Through these implementations, a model farm based on the participatory modeled case could take over a pioneer role in the debate of gender in the agricultural context including the HH-level of farms.

OAG. Concerning the OAG the observation and the workshops created a different picture about the motivation of the participants. A key element observed with the workshops of the OAG is the factor of learning and meaningfulness. In all groups has been consensus about learning as a motivation to join the PM process. In the OAG the motivations were uniformly rooted in professional objectives. The fact that about half of the participants of the OAG show an interest about organic farming as pathway to adapt to the changing climatic circumstances, to enable subsistence and independence of the Ethiopian agricultural sector, indicates a deeper concern about the agricultural future. Special about the handling of the expectations about learning is that the participants themselves created the content what and about which they learned. The assumption that all necessary disciplinary knowledge lies within the group leads to the conclusion that there is need for a container to exchange that knowledge. This has been given by organic farming in form of the PM process. The understanding of organic farming as an inter- and transdisciplinary framework offers the opportunity to bring disciplines and fields together and open the discussion and exchange towards all directions.

In a broader context, the motivation of the OAG shows a clear professional picture that enlarges the diversity of agricultural understanding of the participants. Through the PM and the exchanged knowledge organic farming embedded in a wider extent in the research and teaching sector. Through more people knowing and acknowledging organic farming as an agricultural practice it gets fostered first on a research and teaching level. In an ideal scenario, the knowledge would percolate through the institutions down to the practitioners. Therefore, further research is required to ensure this transition and fostering of organic farming in the research and teaching sector and to understand and improve the integration of motivation towards organic.

After the study. To revise if organic farming could be fostered in the research and teaching through this research it is important to first mention that after the field work the OAG as well as the gender group had no follow-up meetings. Nevertheless, three of the gender group members are now involved in PhD programs focusing on the gender situation in the agricultural sectors. The OAG – as far as known – continues in form of the friendship that has been made throughout the field work but not on professional level. Without an institutional recognition and investment – e.g. a division of organic farming at university – in the sector of organic farming the chances that research towards organic farming keeps being a spin-off of agricultural research are very high. The responsibility to cope with these patterns is embedded at university level and can only be supported – but not owned – by foreign researchers.

7.5 Context and outlook

In a broader context, the results of this study have an impact on the possibilities of participant engagement, their perspectives of agricultural practices and finally the models' application. Through this modelling process, organic farming, which is not well known in Ethiopia and often associated to European markets, has the opportunity to change this perception and its overall recognition. Through the workshops conducted by the OAG, once the principles are understood and potential benefits for local farmers are seen, organic farming is more likely to be perceived as an option to support smallholders and their livelihoods. To understand the underlying processes, it is important to revise the understanding of organic farming in the local context. In different surroundings the definition, knowledge about or practices of organic farming are varying. Through the conducted workshops with the local researchers it became clear that the overall perception of organic farming in Ethiopia is one linked to economic questions excluding the aspects of resilience through a more stable ecosystem.

Through work with local participants – and finally understanding the actual perception of farmers and researchers in the field – this study contributes to the appreciation of the role of organic farming as an agricultural practice supporting in first instance local ecosystems and livelihoods. In that sense, participatory modelling creates an opportunity to change the external perceptions and attitudes regarding organic farming. The PM method is more likely to trigger a shift in the mindset of local participants and in organic farming practices rather than finding short-term solutions. The opportunity to understand and reflect upon organic farming practices combined with the appreciation and integration of local expertise engages a shared and cherished learning process.

Through PM – as conducted in this study –organic farming practices are promoted through a local perspective bringing the interest and expertise of smallholders and local research to the foreground. To ensure the triangulation of results, local perspectives have been supported by different local, national and international experts. Out of this study it is perceived as non-expedient to design participatory processes in any sense extractive concerning information gathering. A participant will engage in the communication with the facilitator and other participants if she or he and the contribution is appreciated and valued. It is obvious that in a development context this approach is hard to realize since clear outcomes are expected in the projects in the context of development. Nevertheless, for a development of the research and teaching sector towards more holistic thinking and approaches the necessity of projects is given, that connect disciplines and create holistic pictures of problems rather than specializing in particular disciplines – especially in the agricultural sector. Integrating disciplines and different fields in processes – like described in this study – enhances the exchange of the knowledge. In the workshops of this study it has been shown how benefiting a common process can be through inter- and transdisciplinary exchanges. This could be displayed through the interdisciplinary modelling process which provides a framework where e.g. a researcher of the fishery department could come up with an idea about the use of the stored irrigation water as ponds for fishing to increase the diversity of income sources. In the transdisciplinary gender group innovations have been named to have main impacts on the female role in the HH and agricultural sector. Through this a certain standard could be modeled in the budget of the model farm to showcase how small innovations like a washing machine or a water storage influence the daily life of women in agriculture and HH. It is not about revolutionary changing certain patterns in society but enhancing little pathways tackling social inequality to demonstrate how effective interventions can be. In this case, it shows how integrating different perspectives of various fields in a modelling process can help to overcome social inequity. In this participatory modelling process the integration of a gender perspective contributed to the awareness creation of all involved participants.

Facing the outlook of organic farming at BDU and in general in the research and teaching field it should be stated that the continuity of the topic is very low. The reasons – discussed earlier – are enforced by the low level of acknowledgement these groups are receiving by BDU. The actual plan of pioneering an organic model farm with the BDU – based on the model created in this study – has not been continued due to the lack of finances. This shows clearly the boundaries of possibilities concerning this study. Not only on this management and social level the boundaries of the study are restricting a further development of the organic farming sector in research and teaching. On the technical side the constraints of this research are closely linked to (1) the time of the field work and (2) the technical capability of the researcher. Considering the time frame of this study the field work has been about three month and is not meant to be prolonged. This is a crucial detrimental factor since the expectation to create a model within three months accompanied with guiding workshops is a challenging task. Therefore, the refinement of the model with the field work data has been adapted after the field work. There is still space for improvement and for another deeper level of modelling within the existing model. Even though the model is now technically working and modelling the general overview and interactions of a farm according to the organic principles, future research need to be done about how to increase the level of automatic updates and countercheck the level of detail that is applied – e.g. by computer-based programming. Furthermore, the next logical steps concerning the participatory groups are follow-up meetings to engage the participants in the further development of the farm and ensure the continuous exchange of knowledge. Ideally, the participants could be part of the realization process of a university organic model farm. Through this the exchange between disciplines and field is ensured and research could contribute through on-farm trainings and workshops to the improvement of farmers' situation in the Amhara Region.

8 CONCLUSION

This study shows that the communication between inter- and transdisciplinary actors can be engaged by using the IFOAM and FAO organic principles as an underlying contextual base. The different stakeholders involved in this study exchanged knowledge through attending the workshops and sharing the outcomes– as workshops were conducted with different stakeholder groups. Integrating different disciplines in the workshops enhanced the interdisciplinary discussion concerning potential and actual on-farm interactions following the organic principles and its systemic understanding of farming systems. Exchanging such finding with gender-oriented stakeholders enabled a transdisciplinary debate and offered the input of a gender perspective in the agricultural sector. Through sharing the outcomes of the individual groups with experts, practitioners and the groups themselves, all involved actors were able to learn and achieve the same standard of knowledge towards organic farming.

Currently, participatory modelling in organic farming is still a pioneer practice. This study shows how organic farming can be fostered through a participatory modelling method with inter- and transdisciplinary exchange on a research and teaching level. Within this study participatory modelling has been used as a tool to introduce organic farming practices to the participants of workshops. At the same time the introduced organic principles have been a base for the inter- and transdisciplinary understanding and exchange in the workshops.

For this exchange the method of participatory modelling has served well. With this approach, hard and soft systems thinking have been merged to create an integrated method. This was seen when linear programming was combined with social components in the early stage of the model development. These social components can be understood as part of system dynamics – classically seen as hard systems thinking. The integration of workshops and meetings with different inter- and transdisciplinary individuals and groups in the model development entails soft systems thinking criteria regarding social accessibility and local acknowledgement. Workshops with locals in the early stage of the model development reduced the probability of later adaptions in the model since the ideas and objections were embedded early on in the process. The participatory modelling process encourages the hypothesis that hard and soft systems thinking do not exclude each other. These two theories rather create synergies when applied together in research or projects like this study.

This study showed that through participatory modelling the timing of involving stakeholders and participants has a crucial impact on the outcome of the study. In this case, stakeholder involvement took place at an early stage of the model development. This afforded the opportunity for the modeler to integrate stakeholder ideas, restrictions and adaptions to the local conditions at the beginning of the modelling process. This way a more holistic consideration was assured. Conducting the workshops with (1) the organic advisory group and (2) the gender group has different reasons on the side of the facilitator – e.g. focusing on gender related topics – but also on the side of the participants – e.g. the creation of a safe space for exchange. The understanding and analysis of the motivation of the participants in the workshops increases the facilitators' ability to better satisfy and integrate the needs of the participants. The motivation of the OAG to participate in the workshops is a link between the professional and personal level. Professionally organic farming and the understanding of its principles offers certain opportunities but has been rooted in a private interest in first instance. The motivation to learn about organic farming as such, and to contribute to the improvement of farmers' agricultural and economic situation, are the two main motivations of the OAG. An advantage of this perspective was identified through the integration of the group from the very beginning of the research so that the OAG automatically followed the whole process and all sub-systems integrated in the organic model. Within the gender group the picture developed differently. The integration of the female participants in the gender group was mainly motivated by contributing toward the end of the deplorable state of affairs regarding the gender situation in the agricultural context. Another crucial factor for the motivation has been the rare safe space the study created for an open exchange. In this study the participants in the gender group showed appreciation of the gender topic as it triggered personal experiences and is embedded in the identity of the participants.

There is a general demand for further research in the sector of participatory modelling as well as how this method can be used as a connection between different disciplines and fields. In particular, how this method integrates organic farming in the research and teaching sector and helps to change agricultural perceptions and practices is of high interest. Until obstacles at universities concerning the acknowledgement of organic farming as a field are removed, the research and teaching of organic farming will be limited. A showcase or model farm may help to create scientific acknowledgement and broaden the inter- and transdisciplinary exchange towards organic farming.

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10 ANNEX

10.1 Location identification process

In the following the process of the location finding will be explained. The request as been made during the field work from BDU to start the administrative process. Therefore, certain criteria have been set which are described in the chapter *The Process.* Following are the different steps of the identification process to ensure transparency about the identification process.

10.1.1 The Process

This chapter describes the process of the identification of suitable land for an organic model farm out of physical and ethical parameters. The constraint of this process is linked to the Ethiopian property laws for land. According to those there is no such thing as property and farmers can only lease their land for a maximum of 25 years. Additionally, the government is able to buy the land back if there are governmental purposes the land is needed for. The location for the organic model farm is aiming to not struggle with these circumstances. So the goal is to identify unused and unoccupied land so that there is no interference with the local community. This is not only out of an ethical perspective important but of a social integration perspective. If the farm is going to be a show case for farmers of the surrounding it is important to avoid negative recognition throughout the community. Furthermore, there are several natural criteria described in the following. Through an identification process with different local groups, water experts and administrative responsible bodies three potential sides could be identified.

10.1.1.1 Step 1 –The Criteria

The criteria selection process for the location is based on the expert knowledge of agricultural practitioners. The criteria include the following issues:

1) Gradient of the area
2) Vegetation of the area
3) Landuse History
4) Water availability
5) Soil conditions
6) Infrastructure

To find the best set of criteria for each the farm the following indications have been of interest.

10.1.1.1.1 Gradient of the area

The slope of the area should no exceed a 2% gradient due to the increased runoff rates during rainfall events. With this gradient and an appropriate soil cover like it is planned for the demonstration farm, water can still infiltrate and runoff losses as well as top soil loss will be minimized.

10.1.1.1.2 Vegetation of the area

The present vegetation is aimed to increase the soil fertility and to enhance the soil and water conservation. In an optimal case the area is occupied by some trees which loosen the soil and can be integrated in the demonstration farm. Any crop cover at all can be seen as advantage for the future agricultural practices. The current vegetation is not an exclusive factor for the decision making process but can be considered as value adding.

10.1.1.1.3 Landuse History

The current and past landuse patterns of the area for the demonstration farm have a crucial role in the definition of the plots. Due to former landuse practices the soil fertility and natural resources have been influenced and might take impact on future practices. Essentially are the practices of fertilizing, using pesticides and herbicides, ploughing and other soil fertility influencing practices.

10.1.1.1.4 Water availability

A crucial factor for agricultural practices is the water availability for plant growth. Depending on the water resources the cultivation is influenced to an essential extent. With water resources like open waters or ground water access a higher productivity and efficiency – also economically – of the whole system can be reached. Nevertheless, the water availability is a crucial factor concerning the choice of crops cultivated on the farm. Productivity is not necessarily lower with less water availability but different. Under more dry circumstances the alley density rises and soil and water conservation practices are increased to ensure the fertility. Since the demonstration farm has a research purpose the water availability is a crucial factor concerning the choice of the plot since a given necessity is essential for the flexibility of research cultivation.

10.1.1.1.5 Soil conditions

The factor of soil conditions might be one of the most crucial issue concerning the choice of the area. The current soil conditions might determine preparation practices of the land that can take up to several years to reactivate the soil activity. Major issues are here the kind of soil, the soil depth, the pH, nutritional values and soil fertility. There will be a green manuring period in the set up of the farm but that is aimed to be as short as possible to get in a productive state as soon as possible.

10.1.1.1.6 Infrastructure

The factor of infrastructure is as well of great importance since the demonstration farm will be used by several researchers and stakeholder for educational and training purpose. Additionally, the processed goods need a way of transportation to the local markets, laboratories and the university. So it is essential that there is an easy access to the farm. Ideal would be an area which is close to one of the main roads in the area where students can be brought by public transport since the aim is to install a research farm.

10.1.1.2 Step 2 – Local & International Consultation

In step 2 a consultation of local and international experts is taking place where the future process is discussed concerning the integration of field visits and satellite data. Therefore, the Small Scale and Micro irrigation Support Project (SMIS) and the Water and Land Resource Centre (WLRC) are aimed to be contacted.

The junior expert MSc. Doris Wendt from SMIS is particular working on satellite data for irrigation projects in the Amhara region. This Includes field visits and the cooperation with local experts from the ministry of agriculture. Satellite data can be provided by SMIS and WLRC.

Together with the experts a design for the further steps in the identification process will define the procedure. The outcome is as described in the the following steps

10.1.1.3 Step 3 – Preparation of maps with possible areas

The process continues with satellite data analysis concerning the area within 40 km around Bahir Dar. Due to the consultation of the experts from SMIS this is done with open resource data from the area provided by different local institutions like the WLRI, SMIS, the ministry of agriculture and additionally Google Earth. Since the data bases are of very low resolution and quality the use of GIS data is unfortunately not applicable for the area.

Maps will be prepared with the essential information about:

- The potential radius around Bahir Dar
- Landuse
- Connectivity to infrastructure
- Water availability (Groundwater, open water)
- Local Communities

These maps are consulted by the international experts concerning the technique and application. This consultation is non-judgemental and concerns only the technical application of the selected methods.

10.1.1.4 Step 4 – Pre-selection of the possible areas

The maps that are constructed in the previous step are now analysed and it is tried to make a pre-selection of possible areas that might be suitable for the farm. That excludes existing farms, infrastructure and other already occupied land. There should be around 10 different plots that fit to the criteria as much as possible.

10.1.1.5 Step 5 – Consultation with the local expert group for organic farming

In that phase the prepared maps will be consulted by the advisory group for organic farming of the Bahir Dar University (BDU). Within this group different departments are represented and each contributes with specific knowledge about a certain subject. The criteria mentioned in step 1 are crucial for the decision-making process. The group is taking a close look to all these criteria and the pre-selected plots. In this process, the group is aimed to argue about the different subjects and to deliberate about the characteristics of the pre-selected plots. The outcome of this process is a ranking of the plots concerning their suitability for the demonstration farm.

10.1.1.6 Step 6 – Expert analysis

After the process of ranking Professor Bernhard Freyer is authorized by the President of BDU Dr. Baylie, Damtie to make a selection of the sites. These selected sites are chosen based on the procedural knowledge of Prof. Freyer who is since 30 years in the organic farming business and has expertise knowledge about the needs and necessities for such a farm site. Additional site visits might be necessary to evaluate the suitability according to the criteria of the potential area. There should be three to four sites that are a qualified for a closer inspection and community visit.

10.1.1.7 Step 7 – Community Visit

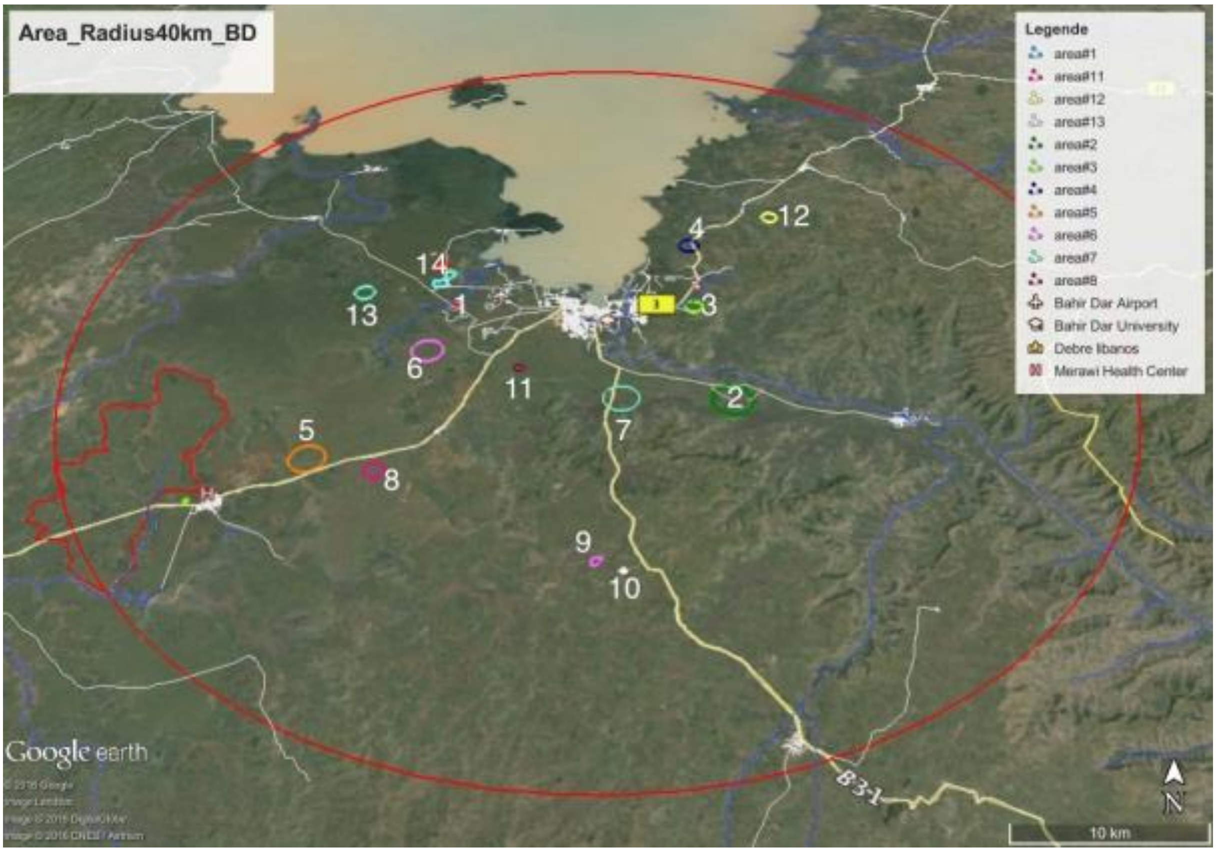
After the identification process of the potential plots in step 6 the project owner at BDU together with the advisory group are meant to visit the site and discuss the issue of a demonstration farm for organic farming of BDU with the local community. Out of this site visit and communication with the local community a clear picture about the willingness, suitability and feasibility. A major constraint is the willingness of the community. It needs to be clearly communicated what the motivation, the expectations and the need of the community is to agree with the instalment of the demonstration farm. Therefore, a neutral facilitator should join the meeting with the community to balance the different interests and to ensure the inclusion of all perspectives.

10.1.2 Completion of the identification

Step 1 of the identification process has been consulted by the SMIS project experts for the identification of the right criteria. All criteria are agreed on with the experts.

Step 2 has helpful in the concerns of local knowledge generation and GIS-data based knowledge. The experts gave advise about the data to be integrated and could even forward existing data packages about the region in regards of landuse practices, water supply, soil fertility, infrastructures and fresh water ways.

In step 3 and 4 the first potential areas have been identified due to the criteria on behalve of the usage of GIS data package available for the area and *google earth pro* images for the completion and triangulation of the collected data. There have been 14 areas selected that are potential areas due to the fulfilment of certain criteria. In the annex the identified areas are mentioned and their fulfilment of the criteria is indicated on the single maps. With a 40km radius around Bahir Dar the areas are located as indicated in the Picture 4: 14 potential areas for the demonstration farm



Picture 4: 14 potential areas for the demonstration farm

In step 5 the potential areas which have been pre-selected were discussed by the OAG in the meeting on the 21st of April. The approach was a collection of pros and cons for every location to create a ranking of the diverse areas. The aim was to identify the 4 most suitable areas. The result is as follows:

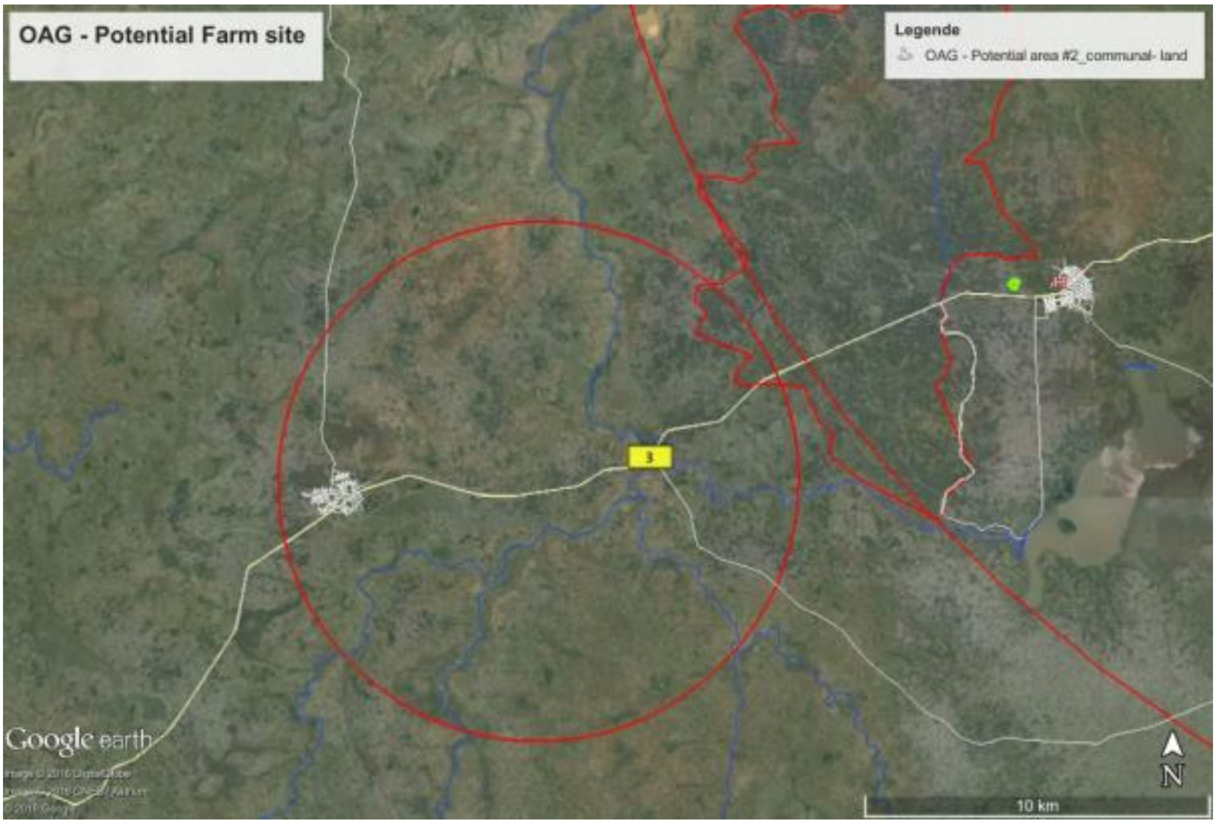
RANK	LOCATION
1	8 (around Meshenti)
2	13 & 6 (in the river catchment)
3	4 (infrastructural advantages)

Tabel 1: Ranking of the pre-selected areas

Additionally, there have been suggestions by the OAG due to administrative issues to also include different locations. The administrative challenges that have been issued by the group were concerning the following issues:

- **Land ownership**; even though there is no ownership as such the ethics of the demonstration farm exclude land grabbing issues. Therefore, it is necessary to search for **communal land**.
- **Infrastructure**; The land identification should be closest as possible to the University to keep the communication and leading of the farm very close and short distance.
- **Availability**; Concerning the OAG there are two institutions that have land on hold for investment. The *land administration office* and the *investment office* are institutions to be contacted and asked for possible potential areas.

Through this discussion there have been two potential areas that fulfil on these criteria. The one is already integrated in the ranking above – it is the rank 1 area close to Meshenti. This area is controlled by the investment office and has therefore potential concerning the current usage. There might not be any interference with local farmers. The second area is a communal area close to the Koga irrigation scheme next to Merawi. The usage of communal land is essentially in small scale local politics due to the potential land grabbing with the current land ownership management. In the following picture the potential areas is indicated.



Picture 5: OAG - Potential farm site #2 - area of Merawi

Beside the OAG another expert has been consulted concerning the issue of water availability – particular ground water availability – in the 40 km radius. The expert is a private consultant of the water supply scheme Bahir Dar, Dr Marou. Due to the information gather within the interview of Dr. Marou, he advised an area close to the east side of Lake Tana because of the rising aquifer in that region. Regarding the map below it can easily be identified that the areas South and South-West of Bahir are not an option for ground water access. There the wells would need to be around 150 to 200 m deep to reach an aquifer delivering enough and constant water supply.

There is the possibility of high ground water levels in particular areas to certain ground water filling processes – as seen in several field visits where ground water level has been around 8m depth (27th April 2016).

Figure 10: Groundwater Flow Bahri Dar, Amhara Region

10.2 Terms of Reference OAG

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Office of the President
Bahir Dar University
Bahir Dar – Ethiopia

Wisdom at the source of the Blue Nile

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ቁጥር / Ref No. 1/10931/1.6.1
ቀን / Date 17/08/08

To: Minnesota Institute for Sustainable Agriculture
University of Minnesota
411 Borlaug Hall
1991 Upper Buford Circle
St. Paul, MN 55108, USA
skype bernhardfreyer

Terms of Reference

Planning of an organic farm for teaching, documentation & research

In the following the T.o.R. of the Group "Planning of an organic farm for teaching, documentation & research" are described.

§1 The objective

Developing an exact plan for an organic farm for teaching, documentation and research. This plan will serve for the implementation of the farm.

§2 The organization

Organization head BDU: President: Dr.BaylieDamtie
Operational head BDU: VC Research and Communication: Dr.Mulunesh Abebe
Operational head for the planning group BOKU: Prof. Bernhard Freyer

Planning Group Members & Function:

Coordination of the planning steps and moderation of the group: Max Manderscheid
Developing of the Farm plan: Max Manderscheid
Advisory group: Senior Scientist BDU – currently open
Advising & discussing the planning progress – Students from diverse departments BDU
Others – experts from outside that will be identified carefully

§3 Requirements for the participation

- Basic knowledge in organic farming
- Interest to make a step forward in this topic
- Stakeholders that are not convinced that organic farming is an option should not participate

§4 Planning Group

Objective

- Integration of local knowledge in the specific field of expertise
- Contribution & advisory of the planning of Max Manderscheid
- Engage participants from different departments
- Local networking with possible partners

Concerning the different expertise and contents that will be discussed in the meetings the participants might be invited selectively.

Setting

- The meetings will be held in the time from 1st April till the 5th June.
- Meetings will be held every 2nd Thursday starting with the 7th of April.
- The room for the meeting should enable an interactive setting and the participation of all members.
- The topic of the meeting can be decided on interactively but is mainly linked to the progress of the planning phase of Max Manderscheid and continuously coordinated with Prof. Bernhard Freyer, who is in close communication with Dr.MuluneshAbebe.
- The moderation of the meeting is with Max Manderscheid

With best Regards,

Baylie Damtie Yeshita (PhD)
President

CC//

- President Office
- Office the Vice President for Research and Community Service
  Bahir Dar University

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In Replying, Please quote our ref. No.

Figure 11: Terms of Reference

10.3 Participant List – Board meeting & Gender Group

NAME	POSITION/INSTITUTE	CONTACTS (PHONE, EMAIL)
1. Melkamu Alemayehu	College of Agriculture & Env. Sciences	melkalem65@gmail.com
2. Yeshambel Mekuriaw	"	Yeshambel166@gmail.com
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GENDER GROUP		
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3- Aman Adane	Graduate assistance Bahir Dar University	amanadane18@gmail.com.
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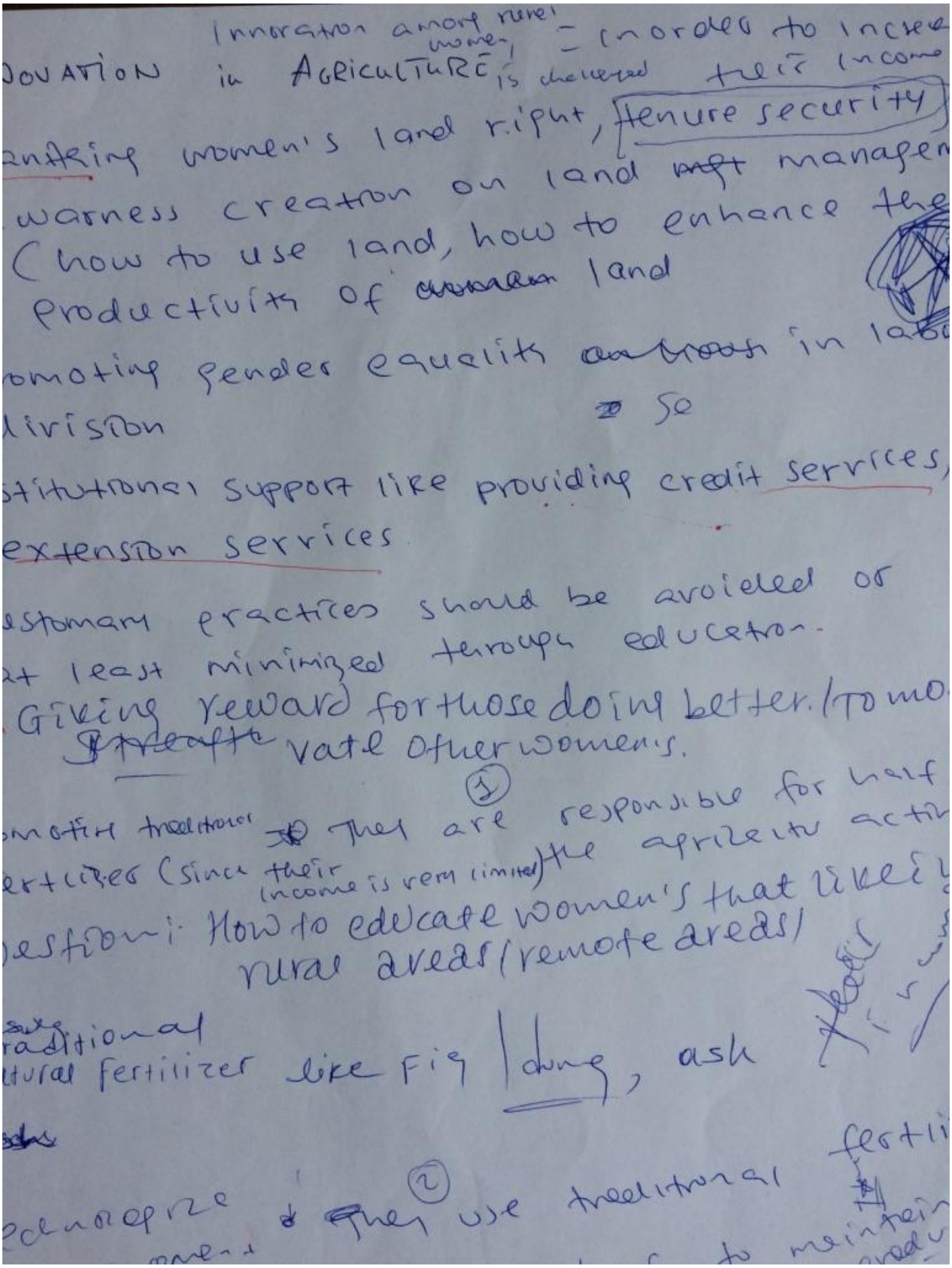
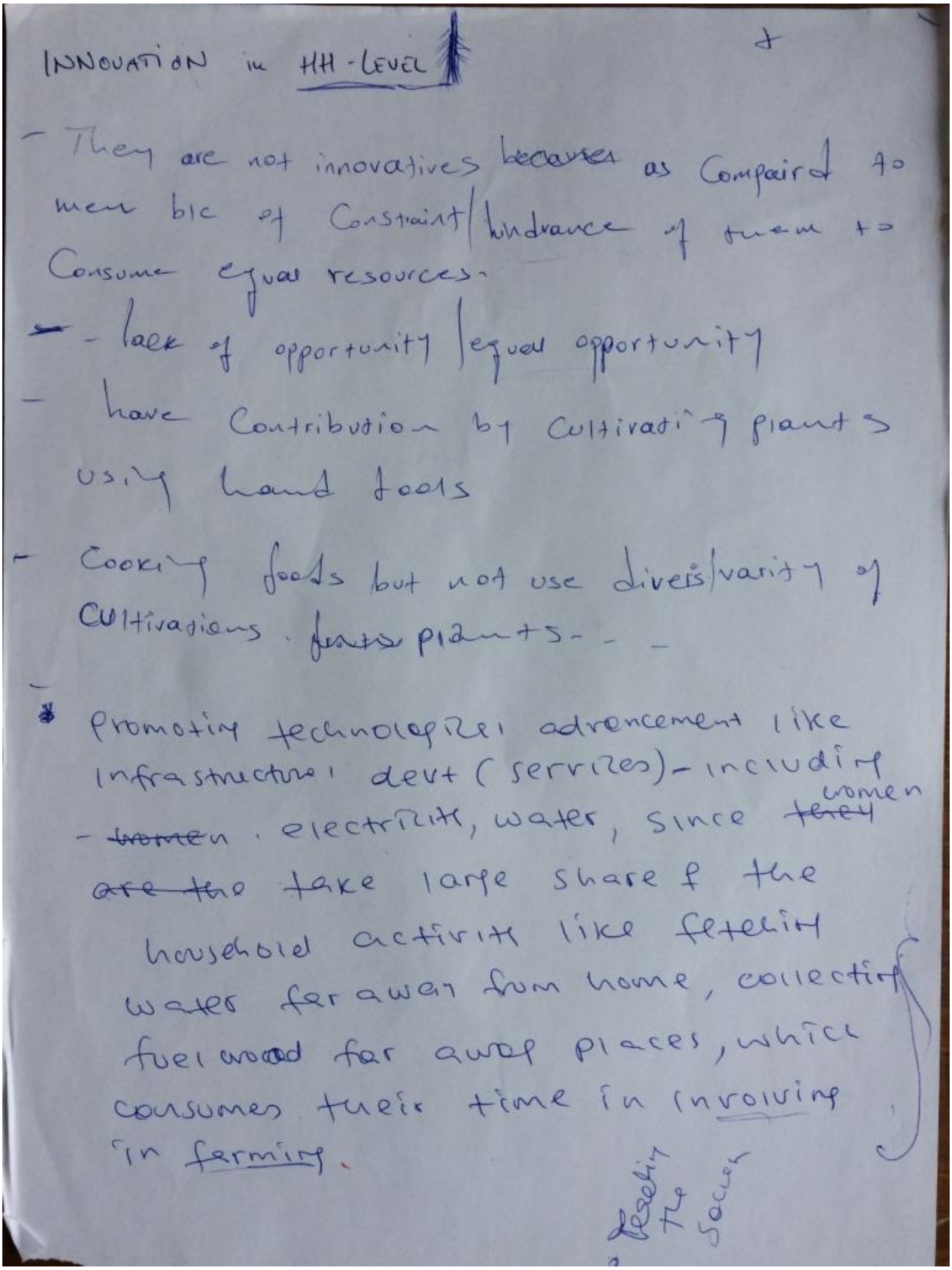
5. Meseret Gebeyehu	Lecturer at BDU (soc.)	mesicool21@yahoo.com 0918726407
6- Marshet Kebede	GA II at BDU (soc)	0923314203 (marshetkebede@gmail.com)
7- Asnakech Admasu	Assistance Lecturer at BDU (soc)	0928445013 / E-mail - asnakechadmasu8@gmail.

Table 41: Attendance list Board meeting & gender

10.4 Documentation gender workshop


innovation among rural women — in order to increase
[illegible]NOVATION in AGRICULTURE is checked their income
[illegible]enforcing women's land right, tenure security
[illegible]warness creation on land ~~mgt~~ managem[illegible]
(how to use land, how to enhance the productivity of ~~[illegible]~~ land
[illegible]omoting gender equality ~~[illegible]~~ in lab[illegible] division
[illegible]stitutional support like providing credit services, extension services
[illegible]ustomary practices should be avoided or at least minimized through education.
Giving reward for those doing better. / To motivate other women's.
① They are responsible for half [illegible] the agriculture activi[illegible] (since their income is very limited)
[illegible]estion: How to educate women's that like rural areas/remote areas/
Traditional natural fertilizer like Fig dung, ash
② They use traditional fertili[illegible] to maintain

Picture 6: Example of notes during gender workshop

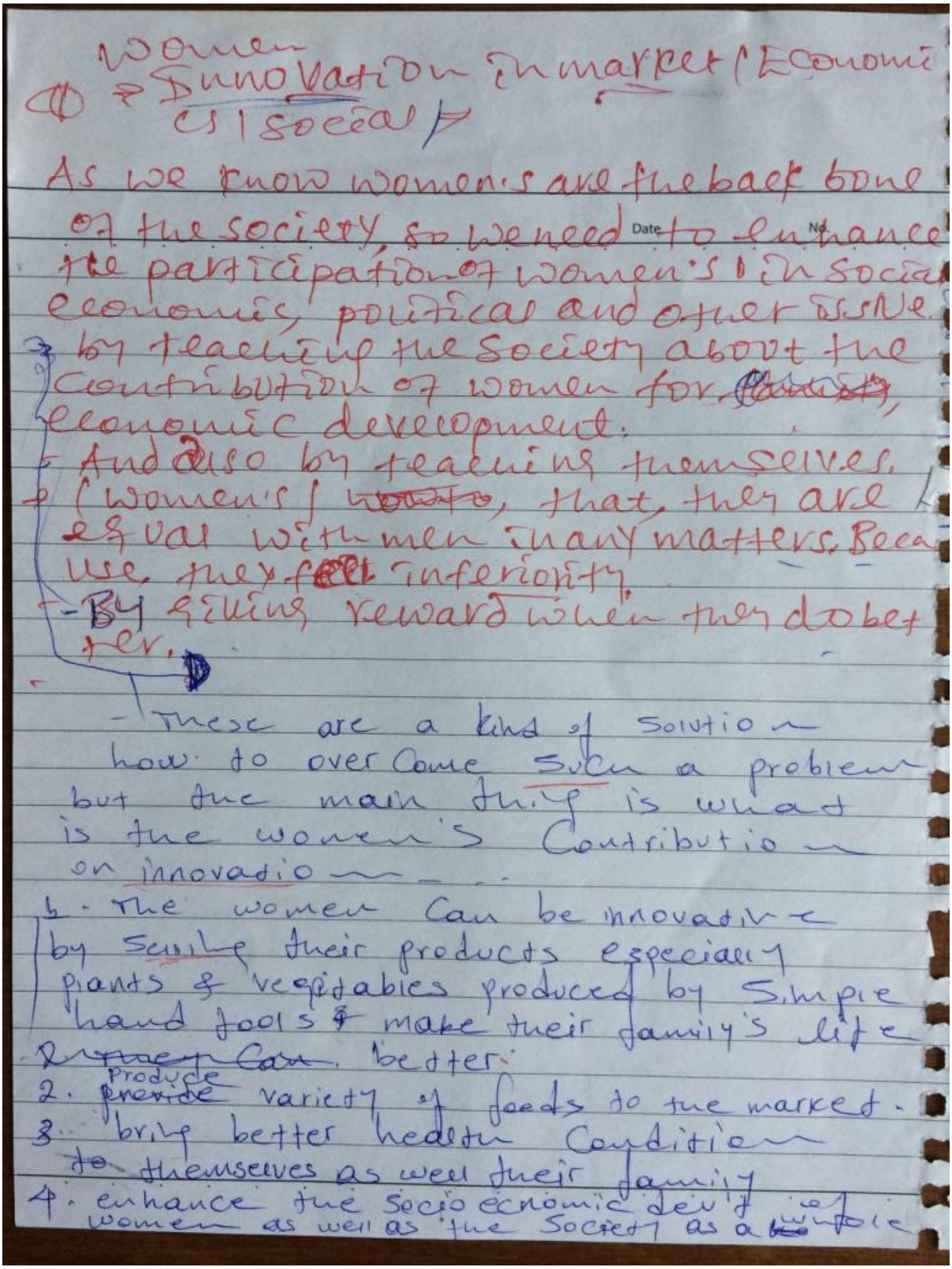

INNOVATION in HH-LEVEL

- They are not innovatives ~~becauses~~ as Compaird to men b/c of Constraint/hindrance of them to Consume equal resources.
- lack of opportunity/equal opportunity
- have Contribution by Cultivating plants using hand tools
- Cooking foods but not use divers/varity of Cultivations ~~fruits~~ plants - - -

* Promoting technologizel advencement like infrastructurel devt (servizes) - including - ~~women~~. electrizity, water, since ~~they~~ women ~~are the~~ take large share f the household activity like fetching water far away from home, collecting fuel wood far away places, which consumes their time in involving in farming.

fetchin the source

Picture 7: Example of notes during gender workshop



(1) Women Innovation in market (Economic/social)

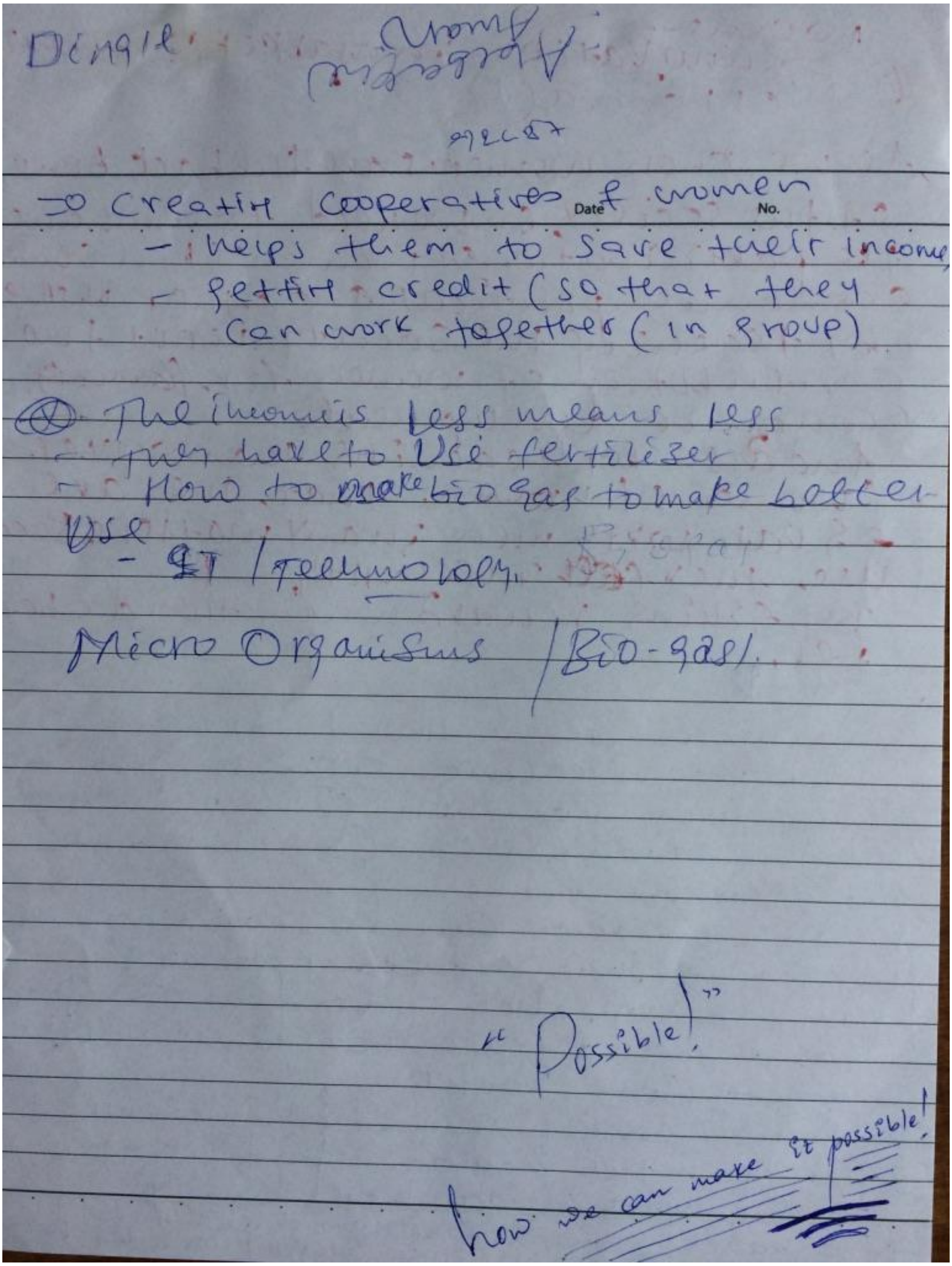
As we know women's are the back bone of the society, so we need to enhance the participation of women's in social economics, political and other issue by teaching the society about the contribution of women for ~~[illegible]~~, economic development.

- And also by teaching themselves (women's) ~~[illegible]~~, that they are equal with men in any matters. Because they feel inferiority.
- By giving reward when they do better.

- These are a kind of solution how to over come such a problem but the main thing is what is the women's contribution on innovation...

1. The women can be innovative by selling their products especially plants & vegetables produced by simple hand tools & make their family's life better.
2. Produce ~~provide~~ variety of foods to the market.
3. bring better health condition ~~to~~ themselves as well their family
4. enhance the socio economic dev't of women as well as the society as a whole

Picture 8: Example of notes during gender workshop


Dingle

=> Creating cooperatives of women Date No.
- helps them to save their income
- getting credit (so that they can work together (in group)

The income is less means less
- they have to use fertilizer
- How to make bio gas to make better use
- IT / Technology.

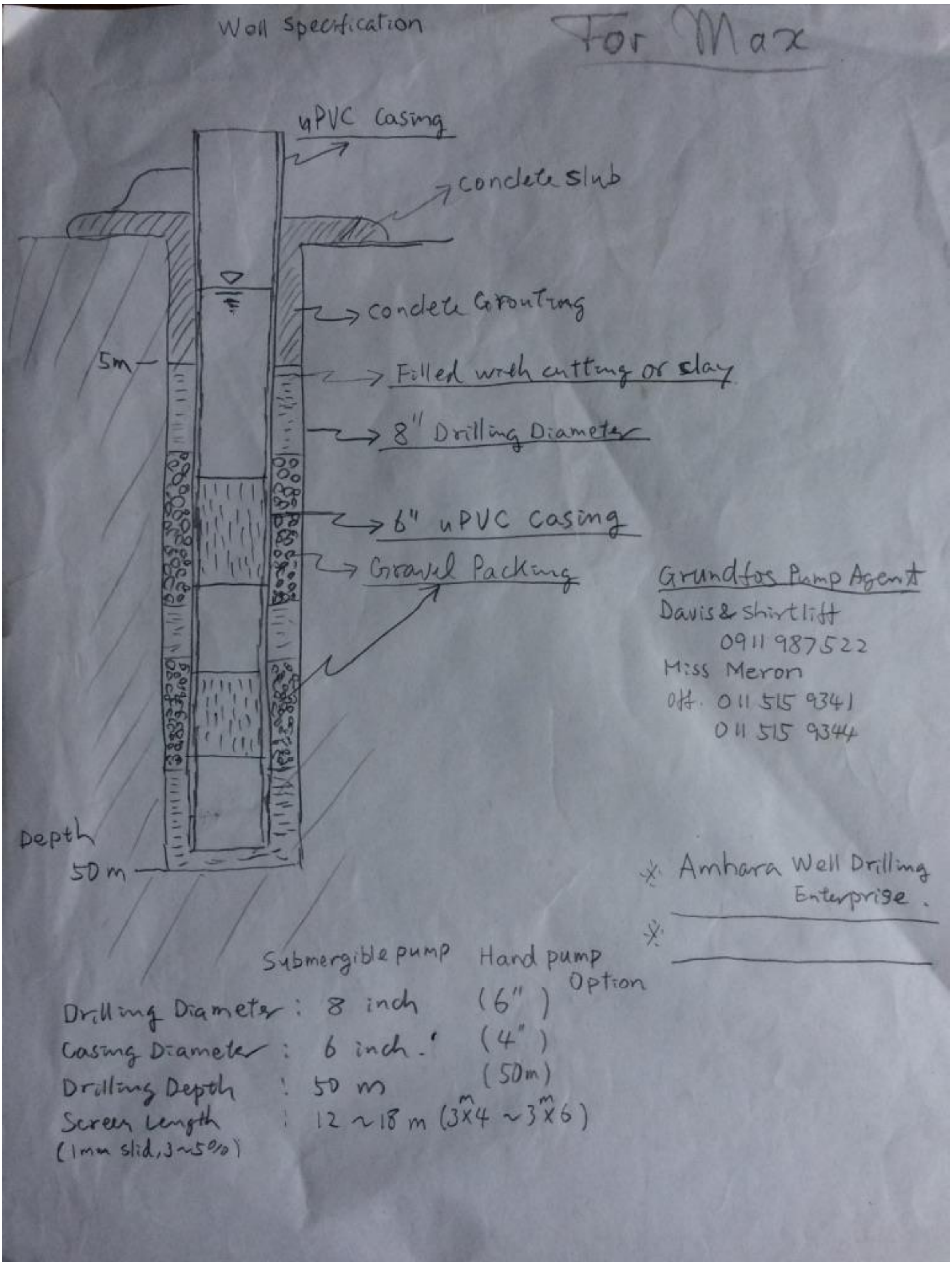
Micro Organisms / Bio-gas/.

"Possible!"

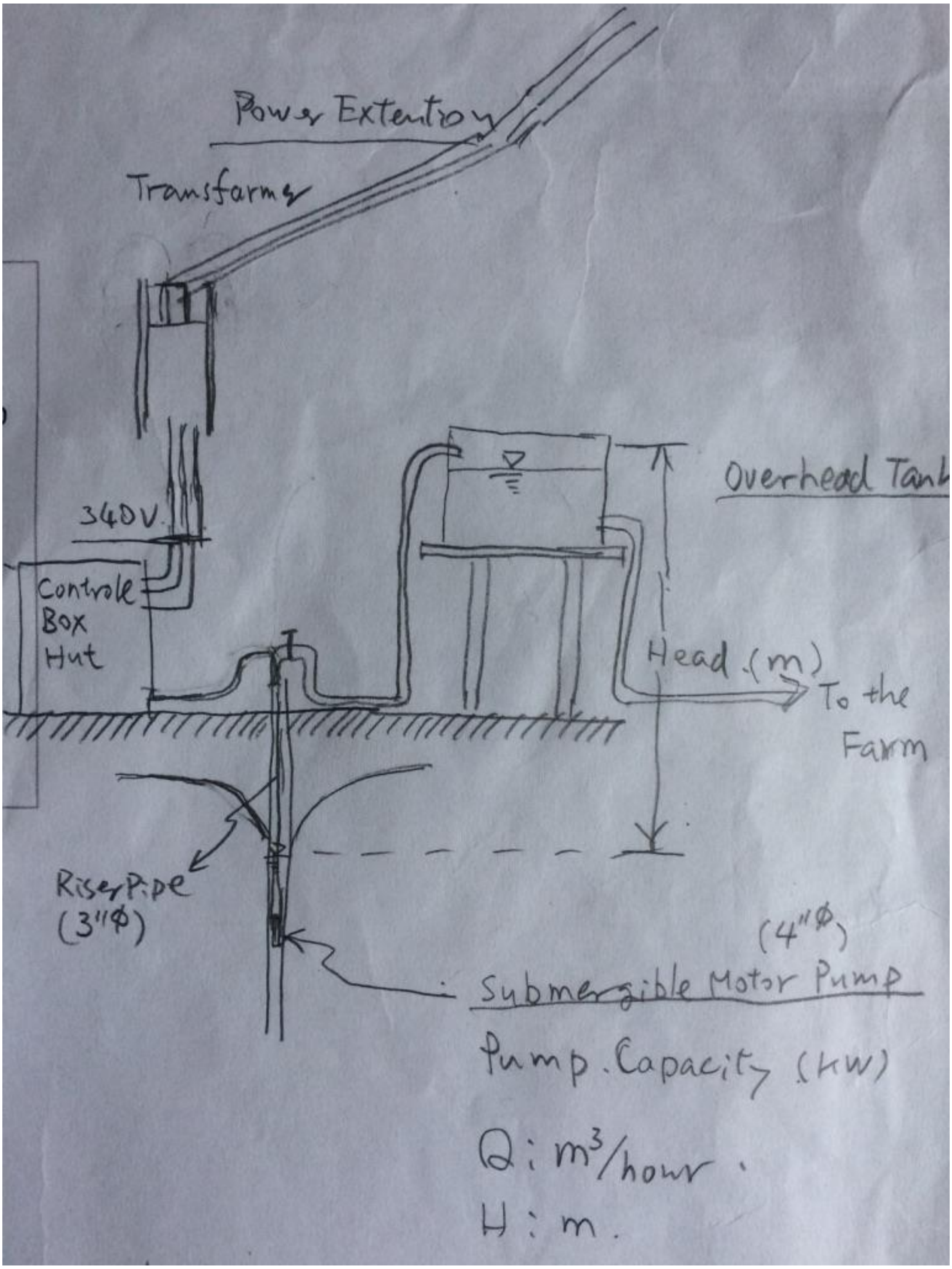
how we can make it possible!

Picture 9: Example of notes during gender workshop

10.5 Pump sketch – Dr. Marou



Picture 10: Well specifications - example



Picture 11: Schematic sketch pump system