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Master Thesis

Participatory Monitoring System for Rainfall Distribution in North East Ghana

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ABSTRACT

It is well known that the climate on our planet is changing and that agriculture needs to adapt. Particularly affected by these changing conditions is the population of developing counties and here especially the small-holder farmers. For a sustainable adaptation to the changing climate it is of great importance to raise the awareness of the affected people on this.

In the course of this study a locally adapted rainfall monitoring system was developed and implemented in five communities of the Chereponi district in the Northern Region of Ghana. The objective was to determine the spatial and temporal rainfall distribution in the five communities. The development and introduction of the measurement system was implemented in form of a participatory approach. The aim was to create an awareness of the changing conditions and the necessity of adaptation, through the involvement of local female farmers. Furthermore, the participation should ensure a long-term rainfall monitoring as well as promoting the empowerment of the women.

The qualitative research design includes the development of the framework of the participatory approach. In total 100 women from five communities participated on this study. 78 semi-structured interviews and nine focus group discussions (FGDs) were conducted. The women were trained in the rainfall monitoring and received one of the developed measurement stations. Furthermore, in the course of the cooperation it was examined to what extent there is awareness for climate change and the adaptation to it.

The results of this study are a successful implementation of 100 measurement stations, each maintained by one woman. Thus, rainfall data since August 2016 are recorded. Additionally, the results of the survey made clear, that there is a local perception of changing climate conditions, but no concrete knowledge or adaptation strategies. It was also found, that the perception of the locals is not always consistent with the meteorological measurements.

In future research it is necessary to investigate whether the developed approach achieves the objectives also in the long-term, and what impact the rainfall monitoring has on the perception of the locals. Furthermore, for an appropriate adaptation on the rainfall distribution, beside rainfall data of the following years other factors like soil properties have to be determined.

Key words: Rainfall monitoring, participatory approach, Ghana, empowerment, awareness, climate change

AUTHOR’S DECLARATION

I,

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Hereby declare on my honour that the attached declaration,

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has been independently prepared, solely with the support of the listed literature references, and that no information has been presented that has not been officially acknowledged.

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Participatory monitoring system for rainfall distribution in North East Ghana

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I. LIST OF CONTENTS

II. LIST OF TABLES

III. LIST OF FIGURES

IV. LIST OF ABBREVIATIONS

AWG	Anoshe Women Group
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Group Discussion
FPR	Farmer Participatory Research
GMET	Ghana Meteorological Agency
NGO	Non-governmental Organization
PAR	Participatory Action Research
PRA	Participatory Rural Appraisal
PTD	Participatory Technology Development
RDA	Rural Development Angles
Coding Focus Group Discussion	
GM1_B	Group meeting Bumburiga
GM(1/2)_A	Group meeting 1 or 2 Ando
GM(1/2)_C	Group meeting 1 or 2 Chere
GM(1/2)_K	Group meeting 1 or 2 Kpaboku
GM(1/2)_N	Group meeting 1 or 2 Nansoni
Coding Interviews	
AR(1-5)/ A(6-20)	Interview Ando woman 1 to 20
C(1-20)	Interview Chere woman 1 to 20
K(1-20)	Interview Kpaboku woman 1 to 20
N(1-2)	Interview Nansoni woman 1 to 20

1. INTRODUCTION

The effect of climate and weather on soil and plants are of great importance for land management. The weather has decisive influence on the interaction between soil fertility, crop and agroecosystem functions [Köppen 2004]. It is well known that the climate is changing all over the world. Therefore, it is imperative that the land management has to be adapt to the changing conditions. For an adequate and sustainable adaptation it is necessary to know how exactly the climate is changing in a particular area. Thus, climate and weather data are needed. Especially affected by climate change are developing counties and in particular Sub-Sahara Africa, due to their dependence on natural resources and rain-fed agriculture [Cobbinah, Anane 2015; Ndamani, Watanabe 2017; Fosu-Mensah et al. 2012]. In particular it is necessary in these countries to have reliable long-term meteorological records on a local level [Dickinson et al. 2016]. But beside the climatic data, the perception of the locals who are affected plays a major role on the adaptation on climate change. If they are not aware of the changes and their impact they will hardy adopt management strategies. Nevertheless, this is frequently not taken into account in the case of externally initiated adaptation strategies, which leads to a lack of understanding on the part of the local population [Derbile, File 2016]. Thus, the involvement of the locals from the beginning is of great importance to raise their consciousness.

This study was part of an interdisciplinary research project within cooperation with a local non-governmental organization (NGO), Anoshe Women Group (AWG). It took place during the farming season from June – October 2016. The cooperation is focused on the development of options for sustainable agriculture in North East Ghana. The study was focused on five communities in the Chereponi district in the Northern region of Ghana (Ando-Kadjura, Bumburiga, Chere-Nakaku, Kpaboku and Nansoni).

Climatic zones are characterized by certain factors that affect soil fertility and yield formation with varying intensity. Among these factors are rainfall amount, intensity and distribution [Köppen 2004]. Therefore, in the course of this study a locally adapted rainfall monitoring system should be developed and implemented in the five communities. Mean annual rainfall data are available for the region, but high-resolution data on the rainfall amount, intensity and distribution is lacking and urgently needed. Furthermore, as the five communities, this research is focused on, are distributed through district, it should be determined whether there are significant differences in the rainfall distribution between these five communities. Additionally, to create awareness in the local population, the project will focus on the participation of the local communities. The overall objective of the study was to create a better understanding of

the climate and climate adapted agriculture and also to empower the women in this region. The philosophy of participatory research is based on empowerment, equity, trust and learning [Reed 2008]. All parties should be included as active contributors in the research process and the researchers should not take dominant role [Reed 2008; Bergold & Thomas 2010]. The benefits of participation can be categorized under normative and pragmatic arguments for stakeholder engagement. Normative claims focus on equity. For example, stakeholder participation reduces the likelihood that they are marginalized and it increases the public trust in decisions. Pragmatic claims focus on the quality and durability of decisions. It is argued that engagement of the stakeholders enables a better adaption to local socio-cultural and environmental condition and it increases the likelihood that local needs and priorities are considered. It is also expected that participatory processes lead to higher quality decisions, as they can be based on more complete information [Reed 2008, Fischer 2000]. Creating a sense of ownership will be possible by involving community members in the whole research process with the aim that they will be able and willing to continue independently.

The objectives of this research study are to develop a long-term monitoring system for rainfall distribution in the member's communities of the AWG in the Chereponi district while collecting rainfall data in the cropping season 2016 and for a long-term study. Additionally, the system is aimed to establish a participatory monitoring system in order to involve the members of the AWG and other locals. Those participating members should be willing to continue with the data collection independently.

The research questions of this study are:

- What is the rainfall amount, intensity and distribution in our research field and the member communities of the AWG in Chereponi district in the 2016 cropping season?
- What are the benefits for the AWG of monitoring rainfall beyond the cropping season 2016?
- What methods would have to be applied to ensure participatory monitoring of rainfall data in the region?
- Which steps will have to be taken to centrally store the collected data and make them available to members?

In order to answer these research questions and to ensure a long-term rainfall monitoring in the region a participatory approach was developed within this project. First of all, the aim and the

purpose of this approach was elaborated and presented to the responsible persons of the AWG and the representatives of the five research communities. Subsequently, appropriate participants for the project were identified. In cooperation with these participants a concept for a locally adapted rainfall monitoring system was developed, implemented and after a testing phase assessed. An additional objective of the collaboration with the locals was the consciousness-raising for the issues of climate and climate adapted agriculture. Thus, in total 9 focus group discussions (FGDs) and 78 semi-structured interviews were held. In order to ensure the rainfall monitoring in the long term, additionally in each community responsible persons were identified and trained to supervise the participants in the communities. Furthermore, a data collector was commissioned to collect the data from the communities and digitize them to make them available to all stakeholders. The framework of this approach was developed during the project and will be discussed and evaluated within this work. Also, the collected rainfall data will be presented and discussed.

2. LITERATURE RIVIEW

2.1 Participatory research

2.1.1 What means participatory research

As this work is focused on a participatory approach it has to be clarified what participatory monitoring means. Participation has a long history in agricultural development [Pretty 1995]. In the 1970s the beginning of participatory approaches took place through incorporation of local perspectives in data collection and planning. Over the time various versions of participatory research have occurred, thus a range of interpretations can be found in the literature and a clear definition cannot be made [Reed 2008; Johnson et al. 2003]. Out of these interpretations, different typologies have been developed. For a better understanding Johnson et al. have summarized four main typologies (Table 1) [Johnson et al. 2003].

Table 1: Typologies of participation [Johnson et al. 2003]

Basis of typology
Typology based on different degrees of participation on a continuum.
Typology based on nature of participation according to the direction of communication flows
Typology based on theoretical basis, essentially distinguishing between normative and/or pragmatic participation
Typology based on the objectives for which participation is used

The first typology is characterized by the degree of engagement of the stakeholder. This can range from passive dissemination of information to active engagement. Compared to this the second typology is more focused on the way of engagement which is defined by the direction that communication flows between parties. In the third typology, it is distinguished between normative and/or pragmatic participation. Normative arguments suggest that people have a democratic right to participate in environmental decision-making. Pragmatic participation argues with higher quality of decision through involvement of stakeholder. The last of these typologies is based on the objective of the use of participation [Reed 2008]. Objectives of the involvement of the beneficiaries can be the development of an appropriate technology which is therefore likely to be adopted. This is understood as “functional research”. Participatory research can also lead to transformation of innovation processes. Through the empowerment of rural population new actors can be involved and the existing power structure can be broke up and rearranged. Participation with this objective is called “empowering” [Johnson et al. 2003]. Lilja & Ashby have characterized participatory approaches based on the five modes of

participation of Biggs and Farrington [Lilja, Ashby 1999]. These are focused on decision making and additionally includes the way of communication (Figure 1) [Johnson et al. 2003].

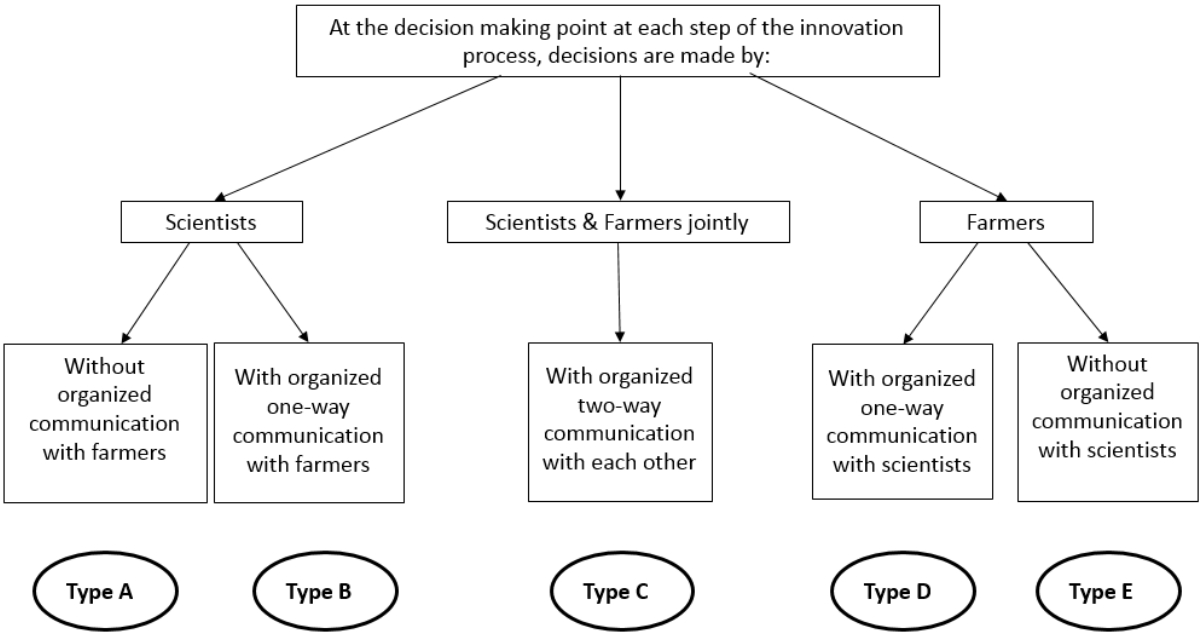

Figure 1: Types of participatory research on Locus of decision-making [Lilja, Ashby 1999]

Organized communication here means a well-defined methodology for implementing a process. If there is no organized communication, such as in Type A and E, the decision-maker takes a decision without consideration of the other sides` perspective. One-way communication is initiated by the decision-maker here in Type B by the scientists and Type D by the farmers whereas the other side respond. The decision-makers know about the opinion, preferences and priorities but are not compelled to take this into account in their decisions. Two-way communication can be initiated by scientists or by farmers and ensures that both sides understand the opinions and ideas or proposals and objectives of each other and the decisions are made together. [Lilja, Ashby 1999].

As it can be seen the interpretation of the term ‘participation’ is wide, Pretty resolved all these interpretations into seven types which are mainly focused on the degree of participation (Table 2) [Pretty 1995].

Table 2: The typology of participation: how people participate in development programs and projects [Pretty 1995]

Manipulative participation – Participation is simply a pretence, with "people's" representatives on official boards but who are unelected and have no power
Passive participation – People participate by being told what has been decided or has already happened. It involves unilateral announcements by an administration or project management without any listening to people´s responses. The information being shared belongs only to external professionals.
Participation by consultation – People participate by being consulted or by answering questions. External agents define problems and information gathering processes, and so control analysis. Such a consultative process does not concede any share in decision making, and professionals are under no obligation to take on board people´s views.
Participation for material incentives – People participate by contributing resources, for example, labour, in return for food, cash or other material incentives. Farmers my provide the fields and labour, but are involved in neither experimentation nor the process of learning. It is very common to see this called participation, yet people have no stake in prolonging technologies or practices when the incentives end.
Functional participation – Participation seen by external agencies as a means to achieve project goals, especially reduced costs. People may participate by forming groups to meet predetermined objectives related to the project. Such involvement may be interactive and involve shared decision making, but tends to arise only after major decisions have already been made by external agents. At worst, local people may still only be co-opted to serve external goals.
Interactive participation –People participate in joint analysis, development of action plans and formation or strengthening of local institution. Participation is seen as a right, not just the means to achieve project goals. The process involves interdisciplinary methodologies that seek multiple perspectives and make use of systemic and structured learning processes. As groups take control over local decisions and determine how available resources are used, so they have a stake in maintaining structures or practices.
Self-mobilization – People participate by taking initiatives independently of external institutions to change systems. They develop contacts with external institutions for resources and technical advice they need, but retain control over how resources are used. Self-mobilization can spread if governments and NGOs provide an enabling framework of

support. Such self-initiated mobilization may or may not challenge existing distributions of wealth and power.

On the one hand, it is suggested that the term ‘Participation’ needs an appropriate classification. And that types like one to four should not be seen as participation [Pretty 1995]. On the other hand, these typologies are seen as judgment and especially terms like manipulative express negative opinions, as it is not always possible, desirable or necessary to achieve the most intense form of participation [Byrne, Alexander 2006]. However, each of these typologies is a base for various methodologies and approaches for participatory research. It can serve as support for the choice of the appropriate method for specific conditions [Reed 2008].

2.1.2 Advantage of participatory research

Participatory research is able to provide the researchers a better understanding of different roles in a complex system. It can provide important information to the researcher as they get to know the users’ priorities, their knowledge, and the factors that conditions farmers’ awareness of access to new technologies. Involvement of stakeholder results in a more appropriate development of an innovation since it provides the opportunity for feedback and adjustments. It contributes to a better fit in particular research sectors, for example in crop management research or developing tools [Martin, Sherington 1997; Johnson et al. 2003]. Involving locals in crop management research, can empower them to better manage their resources, and to evolve sustainable use strategies to improve local livelihood [Danielsen et al. 2009]. Thus, participation is seen to increase the efficiency of a project [Pretty 1995]. It is argued that participatory research shortens the time between the production of new ideas or technology and the opportunity for farmers to test, utilize and reflect back on performance [Martin, Sherington 1997]. From the view of the locals the advantage of participation is in the possibility to meet their interests and distribute scarce resources. Additionally, this process can lead to empower the poor through enhancing the local management capacities, increasing confidence in their potential, and creation of a collective consciousness [Michener 1998]. This also increases the potential for developing local technology-sharing networks which can lead to an exchange of experience [Martin, Sherington 1997]. Because there are many types of participatory approaches they are able to encompass many topics. In addition to its many advantages, it also contains numerous challenges.

2.1.3 Challenges

The intense involvement of local communities into the entire research process presents a number of challenges, ethical as well as practical [Minkler 2004; Cornwall, Jewkes 1995]. The dilemma of many outsiders is that they often need the people's participation as well as they fear it. On the one hand there are a bunch of advantages but on the other it becomes less controllable [Pretty 1995]. Due to the wide use of the term 'participation' there is a similar wide range of expectations about this term. These different expectations of participants can rapidly lead to disappointments, which in turns means that they may not continue their participation, or will not even start to participate because of bad experiences in the past [Barreteau et al. 2010]. Furthermore, local people are sceptical to invest time if they do not see a direct benefit [Cornwall, Jewkes 1995]. Therefore the objectives of the participation have to be clear from the beginning [Reed 2008]. Time constrain is a major challenge in participatory research as most of the methods and approaches are labour intensive and especially the groups of people participatory research is mainly focused on are often lacking in time [Martin, Sherington 1997; Byrne, Alexander 2006; Cornwall, Jewkes 1995]. Many studies which are focused on advantages and disadvantages of user participation, state a lack of motivation and/or self-confidence of the participants as an inhibiting factor [Kujala 2003]. A common problem is that the participants see the needs differently from the researcher and therefore they do not pursue the same objectives. Thus, participation of the communities often appears to be more relevant to the outsiders than to the local people [Cornwall, Jewkes 1995]. Also, sometimes people are just not able to participate due to lacking skills or it limits their individual opportunities to participate for example in a decision making process. The problem is that the capacity to participate is usually assumed, but there is often the necessity to develop them first [Byrne, Alexander 2006]. Furthermore, once participation is defined it does not mean that these will persist for the whole process. Since the engagement and the interest can rise and decline in the course of time, a decreasing participation can always be expected [Cornwall, Jewkes 1995].

For the choice of an appropriate method these challenges always have to be identified in time and considered. And depending on the conditions other challenges can appear as well, as these were just the most common.

2.1.4 Participative methods and approaches

Over time many different participatory methods and approaches have been developed in the context of agriculture [Pretty 1995]. Each of these approaches has the purpose to be suitable for a specific problem or situation to generate a solution. The most known approaches are the

Participatory Rural Appraisal (PRA) [Chambers 1994] and the Participatory Action Research (PAR) [Mapfumo et al. 2013]. These approaches are focused on a community-based situational analysis followed by local action, problem solving and/or project identification. More focused on solving social-technical problems are the approaches of Participatory Technology Development (PTD) [Biggs, Smith 1998] and Farmer Participatory Research (FPR) [Farrington, Martin 1988]. There are numerous more approaches which are not mentioned here [Leeuwis 2000]. Although all these approaches are context specific there are some main characteristics for most of them. All approaches do have methods which focus on a continuous and cumulative learning. All involve the recognition that an interdisciplinary approach serves to a better understanding of the complexity. Additionally, the approach should be flexible enough to suit new conditions and actors. It should facilitate experts and stakeholders to make a changes which improve the situations of the people. And finally all of them should lead to a sustained action [Pretty 1995]. In the literature a wide range of tools and methods of these approaches are found, Chambers summarized them and in table 3 the most common are shown [Chambers 1997].

Table 3: Tools and Methods of Participatory Approaches [Chambers 1997]

Semi-structured interviews – with checklist but without questionnaires which allows a structure of the interview depending on the situation
Key informants – on a particular topic and/or with a special point of view
Key indicators - insights about rural social condition and change
Group interviews – with specialized or focus groups, structured or community groups
Chain of interviews – to observe knowledge of stages of a process or repeat interviews in different contexts
Transects and group walks – visiting and observing diverse conditions
Mapping – using formal maps and/or preparing informal maps based on observation and local knowledge
Diagrams – to express, share and check information
Ranking – to obtain knowledge and preferences from informants
Ethnohistories – recounted by rural people to obtain information about the past
Stories, portraits, and case studies – to constitute the condition, to get a better understanding
Questionnaires – short and simple, and good to analyse

All these methods are focused on the direct interaction between researchers and the end users through dialogue. The choice for the appropriate method is dependent on the objective and the degree of participation [Reed 2008; Johnson et al. 2003].

2.2 Rainfall monitoring and the climate of Ghana

Global climate change has a major impact on agriculture, among other things. As developing countries have a great dependency on agriculture and natural resources these are particularly affected by the changing conditions [Kotir 2011]. One of these countries is Ghana. Ghana has 6 agro-ecological zones that are defined by the climate and thus in turns by the vegetation and soil. Especially northern Ghana suffers from extreme variations of rainfall as well as of the temperature. In northern Ghana changes in the weather and climate conditions have been recognised in the last decades and these changes are subject to regional variance [Trimble, Berkes 2013; Derbile, File 2016; MoFA 2013; FAO 2016].

Numerous studies on climate change and adaptation, are found in the literature. Attention is increasingly paid to the knowledge and assessment of the local population as the impacts of climate change are experienced by local communities [Alexander et al. 2011; Orlove et al. 2010; Riedlinger, Berkes 2001; Derbile, File 2016; Dickinson et al. 2016; Eguavoen 2012]. Also in Ghana and especially in the northern part, several studies about the perception of locals took place and these perceptions were compared to meteorological datasets, although a major challenge was to find reliable long-term meteorological records [Derbile, File 2016; Dickinson et al. 2016; Eguavoen 2012]. All these studies describe similar perceptions of the local communities, although they took place in different regions in northern Ghana. But not all these perceptions could be confirmed with the meteorological records. However, the results suggest that the weather is becoming more and more difficult to predict. It is mentioned that nowadays there is a higher uncertainty and especially the rainfall has become unpredictable [Eguavoen 2012; Derbile, File 2016; Dickinson et al. 2016]. The onset of the rainy season has shifted and is now later. But not only has the timing changed, also the intensity and the geographical coverage. Older generations describe the beginning of the rainy season as heavier in previous years compared to the last 20 year [Derbile, File 2016]. Previously, the rainy season was divided into three seasons, the early rain, the mid-season rain and the late rain. As the beginning of the season has shifted so have these following rainy seasons. Thus, a clear distinction between these is that it is now a major challenge for farmers to determine the optimal date for planting [Derbile, File 2016]. In all studies it is also described that the total amount of rainfall is decreasing. The explained reason for this is the decreasing amount of rain in the peak of the

rainy season between July and August as well as a shortage of the whole season [Dickinson et al. 2016; Eguavoen 2012]. Another interesting perception of the locals is that the geographical coverage of the rain is now smaller. While some years ago several neighbour communities had similar rainfall patterns, this is rare. The locals describe that it is becoming more and more frequently that it is raining in one community, and in the neighbouring community it is not. And even within one community they now determine a different rainfall distribution. According to their memories, in earlier days this was not the case [Derbile, File 2016]. To confirm these statements by meteorological data is hardly possible, since there are no monitoring stations on this local level. Most of the other perceptions agree with the compared data. It has also been noted by the records that the rainy season has shifted and the onset tend to be later in the year. Furthermore, a shortening of the rainy season was ascertained as well as a lower intensity of the rainfalls especially in the beginning [Dickinson et al. 2016; Eguavoen 2012]. However, a decline in the total amount of rain, as it is described by the locals, cannot be confirmed for all regions. On the contrary, according to the records, in some regions an increase in the amount of rain can be observed [Eguavoen 2012]. And forecasts suggest a cyclical pattern of rainfall in all regions of Ghana with increasing and decreasing rainfall [Kotir 2011].

As it was already mentioned, to determine the changing climate conditions, especially on a local level, the major challenge is the lack of measurement stations and thus of long-term reliable meteorological records [Dickinson et al. 2016]. The longest records which were found for this research study are from 1950, recorded at a station 90 km away from the actual study area [Ghana Meteorological Agency (GMET) 2017]. The study area of this project is in the Northern Region of Ghana and its agro-ecological zone is the Guinea Savanna. The mean annual rainfall in this zone is about 1100mm and the growing period of the major season has 180 – 200 days [MoFA 2013]. More detailed data about the rainfall distribution in the Chereponi district is not available.

For the monitoring of the precipitation distribution in a certain area, the influencing factors of the climate have to be considered. The global climate is roughly divided into macro-, meso- and microclimate. The essential characteristics of the macroclimate are determined by the global association of the solar radiation, altitude, land-sea distribution, and the general circulation of the atmosphere. The different climatic zones are based on this. In contrast, the microclimate is the climate in “small areas” or the climate of the “air layer near the ground”. It depends on surface conditions, soil characteristics and soil cover and it may have a wide variety. Between the macro- and the microclimate is the mesoclimate. It is affected by the mountains,

valleys, coasts, as well as forest areas, towns and villages. Statements about small and terrain climatic conditions can be taken by measurements in the terrain. Alternatively, model simulations are applied. For recording climatic differences in small areas a dense station network is needed [Hupfer et al. 2005]. To capture the heterogeneity of the rainfall, the measurement stations have to be distributed accordingly. Since the interaction between soil, vegetation and atmosphere influence the distribution of rainfall, these factors can be taken as a decision aid. Examples of these factors are the type of soil, the soil moisture as well as the land use and the vegetation [Koster 2004].

3. MATERIALS & METHODS

In order to achieve the objective of a rainfall monitoring station which is sustainable and locally adapted the local people must be involved in the approach. To address the research, question the study was divided into two main parts. The technical approach in which the construction of a monitoring station with local materials takes place, and the participatory approach which has the aim to include the locals in the monitoring process.

3.1 Monitoring Station

The system ought to be easy to handle and locally adapted. The aim was to have a simple construction by using readily available materials and tools. Therefore, it was decided to use a plastic bottle with a funnel on the neck of the bottle. This construction was fixed in a 1m high iron mount. The funnel has a diameter of 10 cm. This results in a measuring surface of around 78.54cm². This funnel was fixed on the bottle with a weather-resistant string to prevent theft.

Previous years' measurement showed (based on a small data pool) that the highest amount of rainfall was at around 60 l/m² per day. With a measuring surface of 78.54cm² this corresponds to a volume of 480ml. Because of this and also due to the fact that in a large amount only this are available, 500ml plastic water bottles from the brand Voltic (GH) Limited were used. Although all the bottles are from the same brand there are two different types that were both used. One with a round bottom and thus a cylindrical shape (type 1) and the other with a rectangular bottom, and thus a cuboid shape (type 2) with rounded corners. Also the caps of these two types of bottles are different. Thus, to fix the funnel on bottles of type 2 a hole was cut into the cap and the funnel neck was stick into it and fixed with duct tape. With the caps of the bottles of type 1 this was not possible as the diameter of the cap was too small. Thus, the cap was removed and the neck of the funnel was stick into the neck of the bottle. As these both have the same diameter the funnel was tight. So, the funnel was only tied with a string to prevent theft. Both of these fixing methods ensured that the funnel was horizontal. This is important because if the funnel stands in another angle the measuring surface will change. Therefore, it is also important that the mount stand straight. This was more difficult since the soil in this area is extreme sandy so although the mount was 30cm deep in the ground, it was not tight. So, stones were put into the hole to make it more stable. The funnels were bought in a shop for plastic goods in Tamale. The same type of funnel is also available in Chereponi but not in such a large amount. The bottle was scaled in 20ml steps and therefore water was filled into the bottle and at the appropriate level a waterproof mark was set. To scale the bottle a 10ml syringe was used and the bottle was additionally weighed with a regular kitchen scale from the brand

Zassenhaus which has an accuracy of one gram. The syringe has a standard deviation of 4% which is less than one gram, thus the weighing of bottle was not mandatory. As it was no extra effort, it was still done. The mount for bottle and funnel was made by a local welder. Figure 2 shows a mounted monitoring station how it was used in all five communities.

Figure 2: Rainfall monitoring station C16 in Chere (10°14'15.6"N 0°16'11.6"E). Picture was taken on the 18th of July after the station was mounted.

In each of the five communities 20 of this monitoring stations are mounted. They are placed near by the compounds of the participating women. It was important to ensure that the monitoring station will be not covered for example by trees or buildings. Additionally, it was important for the women that the daily routine around the compound is not affected by the station. Thus, the location for the monitoring station was chosen by each woman herself and it was only ensured by the researcher that there is nothing around which covers the station.

3.2 Documentation material

Each woman received an exercise book for the data collection. Even here the objective was to use locally available materials. In previous years the experience was noted that the farmers are discouraged if they get Excel sheets or other documents to record something. On this account exercise books are used, as these are already known to the women. The exercise books are prepared in order that each page represents one month. On every page the number of days was consecutively numbered. The women were request to record behind each number the appropriate amount of rainfall. For the documentation, they got a pencil in the beginning. This was replaced in the final meeting by a pen. This replacement of pencil for pen was done to work as an incentive to continue with future data collection and also the pencil was difficult to read in the workbooks.

3.3 Participatory approach

To follow the approach for identification of the participants firstly the structure of the hierarchy of the AWG has to be known. The project manager is the head of the NGO AWG. He is responsible on site and contact person for the members as well as for the researcher and the foundation. For his support, there is the coordinator of the Rural Development Angles (RDA). The RDA are representatives of the members in each community. Through them the coordinator is in direct contact with the members. Through regular meetings they inform the head of the organisation how the work is going on in the community and transmit new information they received at the meeting to the other members. In each community as well as the RDA there are male community agents. Their task is it to organize and provide communication between the head of the organization, the researchers and the community. The AWG has 450 female members in five communities. After identification of the participants the further approach was developed in cooperation with them. Therefore, nine FGD and 78 interviews took place.

3.3.1 Identification of the participants

The aim was to involve the community members in the process of monitoring, to ensure that in the long term data collection is also possible even after termination of the cooperation with the researcher. In advance it was considered to work together with the schools in each community. On site the project manager was unconvinced about this idea, he had the opinion that the pupils in the communities are too young for this task. In addition, it transpired that during the project period, pupils were unavailable for most parts because of school holidays. The alternative option was to work directly with the members of the AWG. For this purpose, it was discussed with the project manager and the coordinator of the RDA how to identify appropriate women.

The result of this discussion was that the community agents of each community are the most qualified persons for this work as they are intimate with the spatial and social structures in the communities.

3.3.2 Meeting with the community agents

In the first place the aim of the project and the measuring method were explained. Per community 20 monitoring stations were installed and each of them is respectively to be maintained by one woman. In order to determine rainfall data, the number of 20 measuring stations per community seems to be very high. This is reasoned as a dense observation network is intended. At least two monitoring stations should measure the same in order to have comparative values. It is to be expected that not all the women will continue their work in future and there will be measuring errors especially in the beginning.

Estimated difficulties are that almost all the women can neither read nor write. In addition, the question arises how reliable the women will collect and record the daily value. This was also taken into account for the decision of where the monitoring stations are placed. As close as possible to the fields is desirable. This point was not able to agree with the agents without considering the view of the women. Task of the agents was it to identify 20 women in each community which live spread over the village and are also appropriate and dependably.

3.3.3 First group meeting

After the identification of the participating women by the community agents a first group meeting in each village was held. This first meeting conduced to set the first contact with the women. Targeted questions were asked to determine their actual knowledge about climate, weather and climate adapted agriculture. Through the discussion, they were also lead to the topic of rainfall monitoring and the relevance of it. While explanation of the proposed method the women were also included in the decision making. First of all, it had to be ensured that all of the women are willing to participate on this project, especially as it is a long-term project which is only useful if the data are collected over several years. In this context the women were also asked what motivation they have to participate or what could be an incentive for them. Beside this it had to be ensured that it is possible for all the 20 women to fulfil these tasks. Therefore, the women were asked if they see difficulties in the implementation of this project.

The anticipated challenge was the recording of the data as the majority of the women did not receive a formal education and therefore can neither read nor write or have been in contact with similar tasks. To address this problem the data collection was held as simply as possible. The

women know how to count in their local language thus they should count the strokes on the bottle until the water level. The number of strokes should be then transferred on the correct day, also by means of dashes, into an exercise book which was prepared for them. On days with no rain they recorded a zero and if there was a day where they were not able to check the bottle they recorded an X.

3.3.4 Start of recording

Between the 15th and the 19th of July 80 stations were mounted in Ando, Nansoni, Kpaboku, and Chere. Bumburiga got 20 stations on the 29th of July. Each participant received a monitoring station consisting of the mount, the bottle and a funnel as well as an exercise book and a pencil. Moreover, each woman got a personal instruction how the data collection should be conducted. It was again told that the monitoring station should be checked every day, optimally in the early morning, so that the influence of radiation and high temperature on the loss due to evaporation is as small as possible. Other family members such as the husbands or children were introduced into the work, on their own interest, to support the woman. After a testing phase of 10 to 15 days the data were collected and evaluated. Since problems with the recording of the data could have been ascertained individual interviews with each woman were organized. These interviews aimed to identify individual problems and to find solutions for these. Additionally, the women`s understanding of the project should be further strengthened. At the end of each month the data were collected, stored and used to estimate the success of the interviews and the improvement of the monitoring process. The women in Bumburiga didn´t received further supervision beside the introducing instruction as this community is seen as a reference village. It was used to evaluate how the data collection works without an intensive supervision and the permanent presence of the researcher.

3.3.5 Final meeting

The final meeting took place in October to ascertain what the women have learned in the past four months. They were asked how they would explain their work in this project to a person unfamiliar with the project. It also was discussed if there are further difficulties or challenges and how to handle these. The current farming season was discussed regarding to the rainfall and the expected yield to compare the farmer's assessment to the recorded data. Each woman got a copy of her individual data pool from the last months. Additionally, they received a sign (figure 3) for their station that informed about the purpose of the station and representative organizations. The sign should provide an official character and thereby an additional motivation for the women, it also works as information for the general public. Finally the future approach was visualized on a poster (figure 3). As it is seen as very important that the participants of the project understand it will continue after the departure of the researcher.

Figure 3: Information sign (left) was fixed on every monitoring station and poster of further steps (right) was used to visualize how it will continue after the departure of the researcher. On the top (green) 20 women in the community, middle (red) contact person in the community, right (yellow) data collector in Chereponi, bottom (blue) researcher, and left (yellow/picture) head of the AWG. Small symbols (blue) collected rainfall data, (red) questions and problems, (green) information and answers.

3.4 Contact persons and data collector

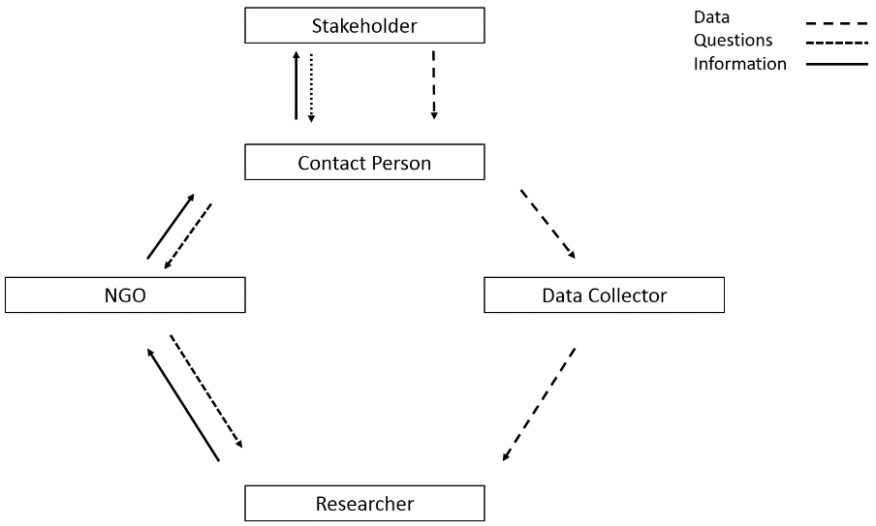

Figure 4: Data (collected rainfall data) and information (information out of the collected rainfall data and answers to any questions or problems regarding the rainfall monitoring) flow.

A contact person in each community and a general data collector were identified in order to ensure that the data collection is continued successfully in the future. And the collected data are available for all participant of the project. The future data and information flow is shown in figure 4.

The contact person in each community is exclusively responsible for the supervision of the 20 women and the data collection in the community. The contact person acts as an intermediary between the women and the organization. However, only in relation to the rainfall measurement. The women can contact him if they have questions or problems. The contact person is trained to help the women with problems in the data collection or the measurement station. If there are other challenges he cannot address, he will send the information to the project manager in Chereponi. As well it is the task of the contact person to collect the recorded data from the women every two months and transmit them to the data collector to Chereponi.

Once a month the contact person observes the women´s records. Here it should be verified if there are any problems with the data collection and if the women record the data on the correct date. Additionally, the measurement station has to be checked, if it is functioning. It has to be controlled if the funnel is clean, the measurement station is still not covered, the strokes are readable and the bottle is not damaged. In case of contaminants or an improper installation of

the measurement station the contact person has to instruct the women to remedy it. In case of damage, repair materials are available at the organization in Chereponi.

It is also a very important task of the contact person to ensure that the measurement stations are mounted correctly before the end of the dry season and that the women continue with data collection. It is important that this happens before the first rain.

The central data collector in Chereponi also stays in contact with the contact persons in each community. Task of the data collector is the collection of the data of all five communities every two months. To store these data and to make them available for every member of the project the data will be entered in a Google Drive excel sheet by the data collector. These sheet is online accessible to the organization, as well as for the foundation and the researcher.

3.5 Data evaluation

The collected rainfall data were digitized and entered into a Google Drive Excel sheet so these will be online available for all stakeholders. For the analysis of the data mainly Microsoft Excel and SAS were used. To compile the graphs Microsoft Excel as well as the ODS Graphics Designer were used. The qualitative data of the FGDs and the interviews were transcribed and manually evaluated.

4. RESULTS

In the following the results of this study are presented. These are divided into two sections. The results of the FGDs, interviews and the participatory approach are presented in the section of the participatory research, and afterwards the recorded and analysed rainfall data are presented. In general the main result is the successful placement of 100 monitoring stations in the five communities, where each station is maintained by one woman. Figure 5 shows the map of the entire area with the monitoring stations in blue, the research fields in green and Chereponi is marked by the yellow stars. In the north-east of Chereponi is Kpaboku. Close to Kpaboku and in the north of Chereponi is Ando. The points in the west surrounding the lake are the stations in Nansoni. North-west of Nansoni is Chere and the points in the north of Wenchiki and close to the border to Togo are the stations in Bumburiga.

4.1 Participatory Research

4.1.1 Participation

Participatory research has different types of participation. In this study the type of participation was not determined in the beginning. This should be established in course of the study and in collaboration with the local communities. The results of this collaboration are described below.

4.1.1.1 Degree of participation

Who will participate and in which degree was not decided in the beginning. For this decision, the local conditions should have been considered. The project manager was consulted and it was declared that the project management preferred the direct involvement of the AWG members. One of the previously favoured approaches was to involve the schools and to establish the rainfall monitoring as a school project, but this was not thought to be a good idea by employees of the AWG. The project manager had the opinion that the pupils in the community schools are too young for this task. Initially, this idea was nevertheless retained as one potential approach. However, finally it had to be rejected due to the fact that during the major part of the project period the schools were on holidays. Thus, it was decided that only members of the AWG participate.

Figure 5: On the top map of Ghana and the study area (framed in white) scale: see fig. [Google Maps 2017], below Chereponi district in the Northern region of Ghana scale: see fig. [Google Maps 2017], representing the five research communities (framed in white) and Chereponi (yellow star) with the rainfall monitoring stations (blue points) and the research fields (yellow).

In order to take into account the local hierarchies the community agents were consulted for the decision of potential participants. These agents have the required knowledge about the structural conditions in the communities and know the members of the AWG, whereby they are able to assess whether the women are suitable for this task. Thus, the agents and the members themselves were empowered to decide who would participate. This was an important point as the participation had to be on a voluntary basis. In the selection of the participants the aspect that the selected participants should live distribute over the whole community had to be considered.

The selected women had to attend a mandatory first group meeting. In this meeting the project and the potential task were introduced. On the basis of this information the women had to decide whether they want to participate or not. In Nansoni a woman said *"To measure it, it will help them as a farmer so we are willing to collect this data because we will get a benefit out of it."* (GM1_N). The statement in Bumburiga was, *"just give us everything and we will start tomorrow."* (GM1_B). Also in Kpaboku the women were willing to participate. One of them said, *"we have to experience how to measure it but we have seen it last year and if the station is not too far I will do it, even if I do not know how to write, we will find children who will help us but you can be sure that everyone will measure it every day."* (GM1_K). In other communities, they first had some further questions, in Ando a women wanted to know, *"do we have to check it every day or just when there was rain?"* (GM1_A), or in Chere they were asking again, *"how can we measure it?"* (GM1_C). Finally, the result was that all of them are willing to participate. On the contrary in some communities there were more than 20 women willing to participate. But to keep it uniform the number of participants was not increased in these communities.

Now as the participants were identified, they also should be involved in the decision process of the project. Thus, they should contribute their own opinion and ideas. Here they were more reluctant and it was difficult to involve them into the discussion. Only several women mentioned some points. One woman in Ando saw a problem in the recording of the data as they are not able to write but she also found a solution for herself. She said, *"the problem is that we cannot write, but we will work with the children."* (GM1_A). To address this problem an additional solution was presented. Counting the strokes on the bottle up to the water level and draw this number of strokes into the exercise book. Here all women confirm that they are able to do this. As it was spoken about the records another woman was asking, *"[…] how will we*

get the results out of this research?" (GM1_A). For this purpose, a solution had to be found in the further progress.

Another decision which was taken by the participants was the location of the monitoring station. It was recommended to mount the stations as close as possible to the fields to get proper information about the amount of rainfall on the fields. However, the distance to the house should be as close that they are able to check the station every day. On the first meeting the women in Ando were motivated to do it perfectly. One of them said, *"we have time, we can even make it if it is far."* (GM1_A) and another one mentioned, *"Our farms are not far from our houses so that is not a problem."* (GM1_A). In Nansoni they were more sceptical and said, *"Some will make it on the field some next to their house. And our houses are close to the farm so if it is like this they will mount it next to the house."* (GM1_N). And for example, in Kpaboku they said directly, *"[…] if it is too fare we cannot check it every day."* (GM1_K). Finally, all the participants decided to mount the station next to their houses.

In course of the discussion, the women draw attention to further problems with regard to the monitoring station. One woman stated, *"It can rain from morning till evening and if she is not around, how can she record it correctly? So, what is if the bottle is full before she can record it?"* (GM1_A). And another on was asking, *"Do you fix the bottle on the top? Putting it on the ground could be a problem because children will take it away."* (GM1_A).

It was also the idea of the participants to involve other family or community members in the work. Almost all of them said that the writing will be no problem as they have pupils who will help them with the recording. In Nansoni one woman also said, *"If something will happen, for example we need to go to the market or we are sick, we can ask our husbands and we can work together with them, so there will be always someone who can check it."* (GM1_N). And also in Bumburiga they spoke about cooperation, *"[…] we will remind each other"* (GM1_B). The women of Kpaboku had a different idea about how they can ensure that everyone is collecting the data correctly, *"we will have meetings every week and there we will ask everyone how the rain was this week and if there is one with no data they will remind them to continue the measurement"* (GM1_K).

The degree of participation was different in each community and also in the group discussion some women were more dedicated than others. Nevertheless, interest was aroused through the discussion. These are results from the first group meeting before the actual start. Whether these

results will be confirmed in the course of the project, will be discussed in the chapter 4.1.1.5 “Progress”.

4.1.1.2 Motivation

In participatory research the motivation of the participants is of great importance. Thus, the participants were asked about motivations. The results are presented below.

The discussion revealed that the participants also see the motivation as a significant part of this work but cannot clearly define a potential motivation for them. Most of them do have material incentives in mind but see it as task of the researcher to decide about an appropriate motivation. They say, *“[…] it is depending on what you want to give us.”* (GM1_K), *“anything you get, you can go and give it to us.”* (GM1_B). But not only materials also *“working together is a motivation and we are also learning from this work […]”* (GM1_A). They additionally see it as a motivation that they *“[…] get a benefit out of it […]”*, *“[…] but to get sure that the work we are doing is done well a motivation can help […]”* (GM1_N). In their opinion the researcher can also use incentives as a control, they say, *“you should come and bring motivation any time you want to make sure that the research goes on […]”* (GM1_A). Basically they say, *“Motivation is important, but there will be no general motivation for all of them […]”* (GM1_C).

These are the results of the first group meeting. After the participants, have started with the data collection and they were working on this for a while, they attended individual interviews. In the interview the participants were asked if they are interested in this work or whether they just doing it because they were asked to do it. The interviews were conducted with all participants except the participants in Bumburiga. Furthermore, one of the 20 women in Nansoni as well as in Kpaboku were not able to attend the interview. Thus, 78 women were questioned. Out of these 78 women 77 said that they are very interested in the work and not only doing it because they were asked. One woman in Nansoni said, *“I´m just checking it because you asked me to do it.”* (N11).

Especially in Ando the women were highly motivated as it is seen in the following statements.

> *“I´m interested in the rain, for example yesterday was it more than today. I want to teach other farmers who are not in the group*.” (AR2).
>
> *“I´m interested because not you need the numbers but it will help us to improve our farming. And for the past I didn´t know how to measure rain but for the future I can*

*teach other farmers in it. I´m not from Ando, so I told my father in another village that I have learned something new." (*A7).

"It is interesting and it also has made a really good relationship between me and my son. Before we got this station he always went out in the morning and we didn´t talk and know we are always checking the bottle together before he goes to the field." (AR4).

"It is not just that I want to know the number I want to know the variety of the rain we have in the village." (AR3).

"I´m interested to learn new methods." (A10).

"I´m interested to know how to measure rain, now I know that last month it only rained 7 times." (A16).

Based on these statements it can be said, that there are a lot of different motivations for the women and also compared to the first meeting the point of view has changed. The women are also not only interested in the work itself, they are also interested in the results. One woman said, *"I´m very interested and I also make always a copy for myself."* (N19). Many of the women stated that or they were asking how they get the results, as their records are collected every month.

The interviews also exhibit that some of the women do the work and they are also interested in it although the aim of data collection is not totally clear for them. One women said, *"I´m interested and I´m happy if there will be water fall inside but I don´t know why we are doing this."* (K17).

The statements of the participants are not the only indicator for the determination their motivation. Rather, the motivation can be seen in the degree of participation and furthermore in the consistency of it. Thus, in the beginning of the project the motivation can be high and in course of the project decrease. To prevent these, appropriate approaches have to be developed, which ensure a sustainable motivation and participation. This is considered in a following chapter "further steps and open questions".

4.1.1.3 State of knowledge of participants

To work with the local farmers and involve them into a project not only the motivation is relevant, it is also important to know their state of knowledge especially in the particular topic of the project. Thus, the aim of the first group meeting was among others to ascertain if climate change is a known term for the participants, if they have realized a change in the climate since

they are working as a farmer and if they know why it is important to monitor rain and how this can help them with their farming activities.

Results of this discussion were that the participants in the communities (except the participants in Bumburiga) are aware of the importance of rainfall and understood that it is important to know how much rain is falling. They also know that rainfall is a significant factor in plant production but a detailed knowledge does not exist. In three of the five villages, the answers were similar. A participant in Ando said "*We know it is important to know how much rain there is to produce crops, but we don´t know how to measure.*" (GM1_A). In Chere they said "*We know it is very important but we don´t know how it can help us.*" (GM1_C).

In Kpaboku the answers were a bit more specified. One participant said, "*It is very important, because they have realized that as they are working as farmers for long they always got successful rain but in the past years the rain stopped earlier and they have realized a shortage of rain and that´s why they know it is important* [to measure rain]" (GM1_K). In Bumburiga the received answer always was that they do not know why it is important to measure rainfall. However, climate change is a well-known term but the participants do not have a precise knowledge about it. They do not make a distinction between weather, annual events and climatic changes. In Nansoni they said, "*The climate changes every year we have rain and full yield and if they don´t get full yield it means they didn´t get enough rain.*" (GM1_N). In this statement, it is also seen that the farmers link their yield with the rainfall, thus the rain is of great importance and there is a great interest on the topic. Often, they refer the term of climate change with the annual differences. One participant in Ando said, "*We are aware of climate change, there are some years where the rain comes early and stops but there are other years where the rain comes regularly and we have successful rain.*" (GM1_A). In Kpaboku it seems to be that the meaning of climate change is clearer. One participant said, "*We have realized that there is climate change, we are in farming for long and there are crops we can´t farm anymore. For example, millet or a specific sort of corn which needs more rain.*" (GM1_K), another one said, "*There is a shortage of the rainy season.*" (GM1_K).

Also, the following statements show that the participants are aware that the climate is changing. In all the communities the participants spoke about a contraction of the rainy season, as the rain starts later than in previous time.

> "*Last year it didn´t rain early and the period was short, but this year the rain came early.*" (GM1_A).

> "*For the past two years we have a shortage of rain.*" (GM1_N).
>
> *"[…]for the last 3 to 4 there are some crops we cannot farm anymore because of the rain, we get less rain."* (GM1_C)
>
> *"[…]we have stopped several crops to farm because the rain starts late […] we just farm crops with a period of three month, crops with six month period we can´t farm."* (GM1_K)
>
> "*The time of planting has changed, we are planting later now because the rain starts later.*" (GM1_B).

But they are not only conscious of temporal differences; they also realize differences in spatial distribution. In Ando they said, "*We have recognized that there are some fields which have more water or where it rains more often than in other fields*". (GM1_A). In Nansoni they *"[…] discuss between each other that there is a difference in the fields, some get more rain than others"*. (GM1_N) and the exchange takes not only place on a community level they also *"[…] discuss it with other people on the market how the rain is in other villages"*. (GM1_N). And also in Bumburiga they say, *"[…] there are some fields where we farm rice because there we get more rain"*. (GM1_B).

As the farmers know the importance of rainfall for their plant production and as they have realized that there are spatial differences and the change of the climate, the questions arise whether they have already developed or applied adaption strategies.

> "*No we make it always the same.*" (GM1_A).
>
> "*We have different crops now than in the past because of the shortage of rain.*" (GM1_N).
>
> "*With the first rainfall we can´t farm because it is too hot, so we have to wait till the second or third rainfall before we can start farming. And then we start with yam.*" (GM1_K).
>
> "*We always start planting with the first heavy rain but we do not always get successful yield, we do not know how to do it right.*" (GM1_B)

Based on these statements it is seen that there is an adaption on the changing conditions. They farm other crops due to the fact that certain crops do not produce yield. In other cases farmers just work as usual as they have learned it from previous generations. Here they realize a

decrease in yield but cannot counteract. The cultivation, especially the planting time is adjusted to the rainfall, for other adaption or water management strategies there is a lack of knowledge.

During field-walks it has been established that there are a lot of fields where they do ridges or intercropping. To the question why they do this, the common answer was, because we always did it or because everyone does it. This shows that the agriculture is mainly based on traditional knowledge and the effect of imitation is also substantial.

4.1.1.4 Challenges

The previous chapter showed a lack of knowledge in the issue of climate and climate adapted agriculture, and also due the fact that all the participants never received a formal education, there were certain challenges which will be discussed in this chapter. The biggest challenge was seen in the illiteracy of many women and that they are not able to record the data. Thus, an alternative method, which was already described in previous chapter, was introduced. Additionally, the women themselves said it will be not a problem, as they also have family members who are able to write and can help them with the recording. Thus, the challenge was not to write the data but rather to record them on the correct date. Often there was the problem, that the women had recorded the data but these could not be assigned to a date and thus where not usable. One woman said, *"I don´t know where and how I have to write it, the translator has explained it to me this way."* (C3). Another one said, *"I had problem with the writing but then they explained it to me again and now I have no problem."* (C11). However, this problem was clarified with each woman in the course of the individual interviews and did not occur in subsequent records.

The evaluation of the data showed that for some measurement stations, which are located at a relatively small distance different values were documented on the same date. Often the difference could be justified by different measuring times, as one woman recorded it in the evening and the other on in the morning. In other cases, however, the difference was not comprehensible. Further challenges could not be identified during the trial period.

4.1.1.5 Progress

In the previous chapters the willingness of participation and the motivation was determined and discussed. To see if these results are confirmed, the progress of the project had to be observed. Therefore, it was looked at the number of received records per month (Table 4) and additionally the women were questioned in the interview as well as in the final meeting if they will continue with the data collection.

Table 4: Number of received records of the 20 women per community

	Ando	Nansoni	Chere	Kpaboku	Bumburiga
July	18	20	14	20	-
August	20	20	15	18	13
September	20	20	20	20	13
October	20	20	20	20	20

Table four shows the progress of the received data. Here it is seen that the communities located close to Chereponi like Ando and Kapaboku had less missing records than Chere and Bumburiga which are located further from Chereponi. Also in Nansoni all data were received. The two missing records in Ando are owed to the case that the women didn´t understand how to record the data. After a second personal instruction, this problem was solved. In Chere a few women had also difficulties with the correct recording. With the individual interviews and instructions which were held at the end of August, this problem was solved and in September records of all women were received. Bumburiga is the furthest community away from Chereponi and during the rainy season due to bad road conditions it can be very difficult to reach. Thus, it was only visited twice. After the placement of the station and an individual instruction on how to record the data, the women there didn´t get any further support. In the first two months seven women in Bumburiga didn't record any data or have problems with the correct documentation. At the end of September, the community agent visited these women in Bumburiga again and made a further instruction how to record the data. In October records from all 100 women were received.

Besides the progress of the data collection, the development of comprehension was evaluated. The result of the survey in the interview was that all the participants are still highly motivated. However, they do not understand the reason of this work. One woman said, *"I´m interested to take part and to continue but I don´t know why it is important* [to measure it for several years]." (K19). Many of the women said, that due to the discussion they understand that it is important to continue with the measurement but they do not know the reason for it. On the other hand, in each community some women mentioned good reasons to continue with the data collection.

> *"If I just measure it for one year how will I know how it change?"* (AR3).

> *"It is good to know the quality and the quantity of rain in every single year, so we will get more experience about the rain and it will help them for their farming."* (N14).

> *"To see how long the rainy season will be because we made this experience that there is a shortage of rain and it will be good to compare the years. It is also good to determine the crops we can grow […]"* (N10).

> *"It is good to know how much it rain in a year, so that we also know how to cultivate our crops. Just this year we started too late, but I´m really happy that you teach us how to measure it."* (C5).

> *"It is a lesson, if I measure it for several years I will get so many experience."* (K15).

These are general reasons for the continuing data collection. They have a logical comprehension that due to the constant change of the weather it is reasonable to document this permanently. But the scientific knowledge does not exist and it proved difficult to impart it. In the individual interviews it was attempted to explain the difference of weather and climate in a simple way. Despite great interest it was hard for them to understand. This is reasoned by the fact that there is no prior knowledge and the time for the workshop was limited.

Also in the final meeting, it was noticed that a basic knowledge about the project exist and in all communities, they saw a great sense in the work, but a detailed knowledge was not imparted. So was the common answer to the question, why they measure the rain, to know how much rain we get in a year or in a month. Also, the answer to the question for what purpose they collect this data was similar. They said, *"I will be able to know how many rains I get in a month or in a year."* (GM2_A) and *"we also know the month it rains more, before we started to measure it, we didn´t know in which month we had more rain."* (GM1_A). In Chere they said, *"[…] to measure the rain is good to determine how the improvement of the crops are and the period we supposed to farm."* (GM2_C). But if they are asked for what exactly this data is used, they are not able to explain it.

The survey showed that the participation is less based on the fact that the participants understand how this can improve their farming, but rather on the motivation of the women to participate in the project and to learn something new. One women said, *"[…] I am really happy about it and I will continue with the measurement even if you come and tell me that I can stop, I will still measure it if I´m alive."* (GM2_A). Another one in Ando said, *"I have also learned how to write, I´m now like a schoolchild because I have access to pencil and a book and therefore I will continue with the measurement even up to ten years if I`m alive."* (GM2_A).

Regardless of the reason for participation it has developed well over the course of time. Except the missing data at the beginning, all the women have participated equally over the period of

time. In the end, from all 100 women data was received. And not only during the presence of the researcher, even after the departure, the data of October and November was collected and transmitted. The question now is, whether the measurement will be continued after the end of the dry season.

4.1.2 Open questions and further steps

To ensure the resumption of the monitoring also in absence of the researcher and especially after the interruption of the dry season, in the last meeting open questions were clarified and further steps were explained.

The main issue of the discussion with the participants was how it goes on in the future. They were asking, *"What should we do in the dry season, should we continue with the writing?"* (GM2_N). The result of this discussion was that if there is absolutely no rain expected in the dry season, they need not continue with recording. As the concerns were also mentioned that the strong winds in the dry season could damage the measurement stations it was decided to dismantle the stations during this time. Due to this the women were asking, *"We do not know exactly when the rain stops, so how long should we leave the station?"* (GM2_A). All the local participants said, that the rain would stop in November. To ensure that every rain is documented the measurement should have been continued till the end of November. The same applies to the end of the dry season, so a woman said, *"[…] next year we have to start earlier"* (GM2_A) since this year the rainy season had already started. The women also wanted to know if next year there would be new researcher who will work with them on this project. As they are highly interested in it but also know that there is still a lack of knowledge.

In order to give them more self-confidence, which also strengthens the motivation, the aim was to convey the participants that their work is an important part of the whole project. To illustrate this and to give this work an official character, each woman received a sign for the measurement station after the testing period (Figure 6). The sign which was explained in chapter 3.3.5 "Final meeting" also served as symbol that the participants know now how to collect the data and are responsible for it.

Figure 6: woman in Nansoni with her monitoring station (N10) after receiving information sign and the collected data, 2nd of October (left) and presentation and fixing of the information sign by the researcher in Ando (monitoring station A20) with the participants and the contact person of Ando, 2nd of October (right).

An additional important issue for the women was how they will get access to the collected data. *"[…] we will continue October and November so how will we get this data?"* (GM2_A). It was explained to them, that the organization always has access to the data and their contact person can transmit the data to them. But they are also free to make their own copy. Additionally, the concept of data and information flow, which was showed in chapter 3.4 "Contact person and Data collector", was presented to the participants (Figure 7).

Figure 7: Final Meeting in Nansoni 2nd of October: Researcher presenting the poster of the further steps to the 20 participating women of Nansoni

The purpose of this concept was to explain to the participants that the contact will be maintained and the cooperation will continue. The visualization provided a better understanding and increased the interest in this discussion. *"Thank you so much […] through this explanation we understand that you will not forget us and we are still in contact."* (GM2_C). The participants were also confident that the project will be sustained in the long term. One woman was even asking, *"[…] I don´t know how long I will be alive, so if I die what will be with my work? Who will continue with this work?"* (GM2_K).

4.1.3 Bumburiga as reference community

Bumburiga is the most secluded community and especially during the rainy season it is difficult to reach. Since it was not sure in the beginning of the project whether it is possible to work with the women in Bumburiga. At the beginning of the rainy season the conditions were as good as it was possible to go to Bumburiga. Thus, it was possible to meet 15 of the 20 women (the north-east part of Bumburiga where five of the women live was not reachable). The first meeting, as in the other four communities, had the aim to set the contact, to present the project and to clarify the willingness of participation. The existing knowledge and the understanding were estimated as the least in Bumburiga. For the main part of the women, the term climate change was not known. And none of the 15 women had an idea why it could be important or helpful to measure rainfall. Also after the explanation of the approach some of the women had a problem to understand it. One woman was asking, *"Should I go every day and pour water in it?"* (GM1_B). However, all women were willing and highly motivated to participate. Thus, a

second visit in Bumburiga was organized and all the women received their monitoring station and the documentation material as well as a detailed, personal instruction how to record the data. Also, this time it was not able to reach the five women in the Northeast of Bumburiga. But members of the community took care that also those received their stations as soon as possible and explained them how to collect the data. This was the last visit in Bumburiga. From now on the women received no further support, either from the research or from their community agent. The data was collected and evaluated only at the end of the trail period. From nine of the 20 women, usable data was received. These had no problem with the data collection even without any supervision. From four of the women data were received which were not comprehensible and it was not possible to dedicate this to a particular date. Form the last seven women no data were received. After this evaluation, another instruction was given by the community agent, who is additional, the contact person of the 20 women in Bumburiga. Finally, the problems seemed to be solved since all data were received in October.

4.2 Rainfall monitoring

4.2.1 Rainfall data

In the following chapter the collected rainfall data are presented. In the communities, Ando, Chere, Kpaboku and Nansoni the data collection has already started in July, to make it comparable with Bumburiga only the data from the 1st of August till the end of October will be considered in this chapter. For Kpaboku the data of 18 measurement stations were used in Chere the data of 16 and in Bumburiga the data of 13, as the other stations´ data were not recorded for the whole period. It is looked at the absolute amount of rain and the monthly average. Additionally, the data are presented cumulatively and the intense rainfall events are separately mentioned.

4.2.1.1 Absolute rainfall

Figure 8 shows the absolute amount of rainfall in the five communities, from the 1st of August till the 31st of October. These data are presented in a boxplot design to illustrate the average of the 20 measurements per community as well as its range. Additionally, a variance analysis of the community was made and the result of this shows that with a p-value of <.0001 there are statistically significant differences between the five communities. In table 5 the results of the pairwise mean comparison are presented.

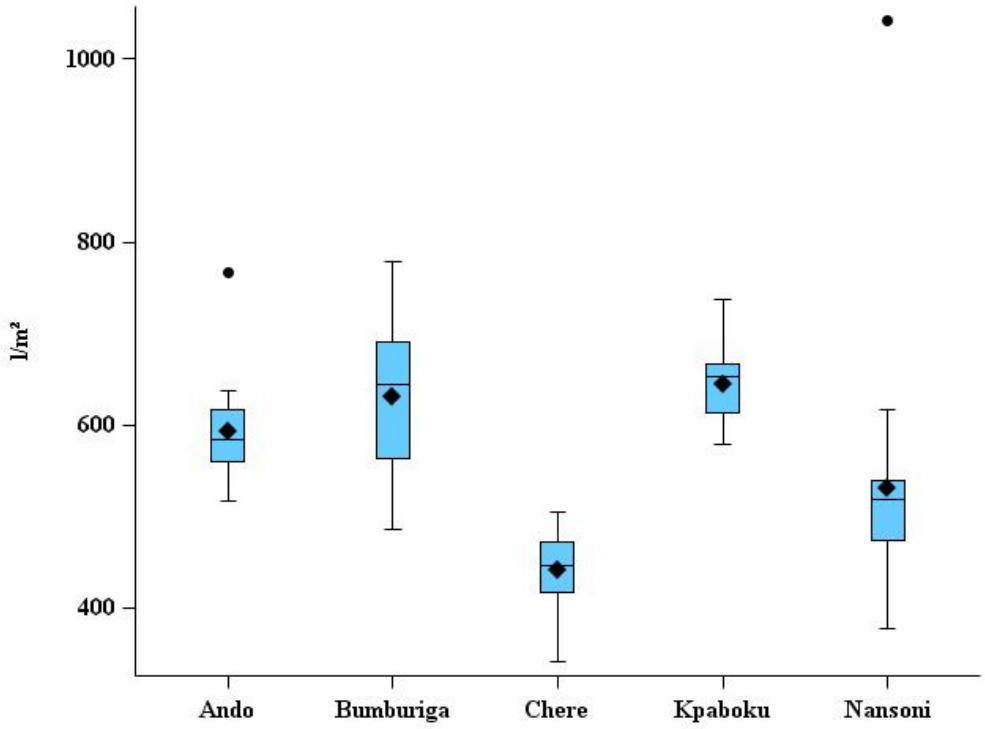

Figure 8: Absolut amount of rainfall in the five research communities from 1st of August until 31st of October 2016

The highest amount of rain between August and October was fallen in Kpaboku with 644 l/m² followed by Bumburiga with 631 l/m². The difference of 13 l/m² over a period of three months can be considered as low, and the p-value of 0.5443 shows no statistically significant difference between these two. The graph also shows the data of the 13 measurement stations in Bumburiga have a minimum of 486 l/m² and a maximum with 779 l/m²the highest range. This can be based on a heterogeneous rainfall distribution in the community or on incorrect recordings. In the following chapter 4.2.2. “Geo statistics” this will be considered. Out of the five communities Kpaboku and Ando do have the nearest distance to each other. The distance between the two closest measurement stations is 1.85km. However, the difference of 51 l/m² is distinct and the p-value of 0.0095 shows a statistically significant difference. The lowest amount of rainfall was recorded in Chere. The differences compared to Ando, Kpaboku and Bumburiga is between 170 – 200 l/m² and a statistically significant difference to all four communities can be determined. With a total amount of 530 l/m² in Nansoni there is also a statistically significant difference compared to the other communities. Finally, it can be said that there is a different rainfall distribution between the five communities. Only between Bumborga and Ando, and as already mentioned between Bumburiga and Kpaboku there was no statistically significant difference observed. Looking at the boxes of the boxplot, which represent 50% of the recorded data, they have (except of Bumburiga) a relatively low range. This suggests a homogeneous

rainfall distribution in the monitored area. To have a deeper look into this the temporal as well as the spatial distribution will be considered. Thus, in the following the five communities are compared regarding their monthly rainfall distribution (Figure 9).

Table 5: Pairwise mean comparison with t-tests (Com=community, A=Ando; B=Bumburiga; C=Chere; K=Kpaboku; N=Nansoni)

Effect	Community	Community	Estimated	SE	t Value	p Value
Com	A	B	-37.6692	20.9117	-1.80	**0.0754**
Com	A	C	151.54	19.6877	7.70	<.0001
Com	A	K	-50.6778	19.0704	-2.66	0.0095
Com	A	N	90.1526	18.8044	4.79	<.0001
Com	B	C	189.21	21.9173	8.63	<.0001
Com	B	K	-13.0085	21.3645	-0.61	**0.5443**
Com	B	N	127.82	21.1274	6.05	<.0001
Com	C	K	-202.22	20.1680	-10.03	<.0001
Com	C	N	-61.3849	19.9166	-3.08	0.0028
Com	K	N	140.83	19.3066	7.29	<.0001

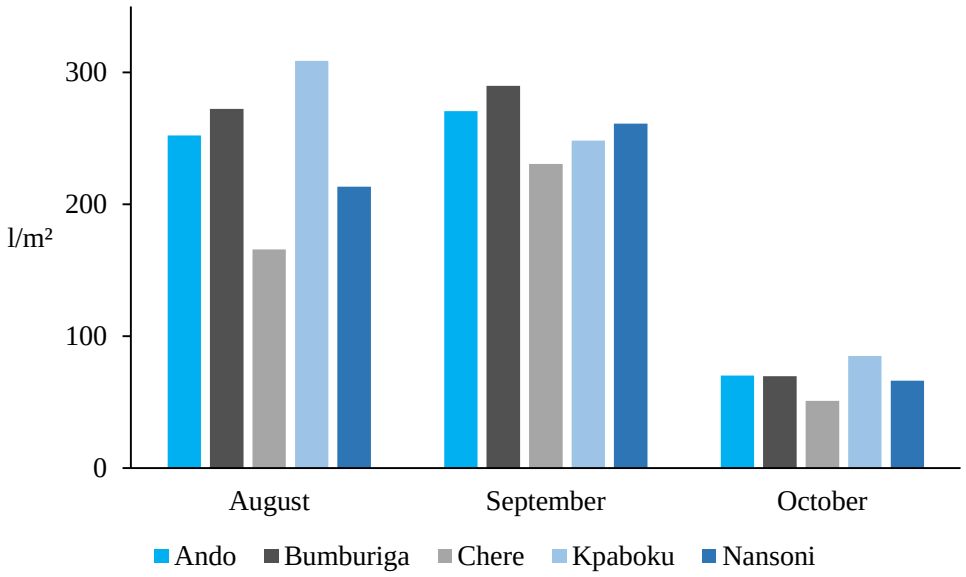

Figure 9: Absolute amount of rainfall per month in the five research communities

As it was mentioned before, Kpaboku and Bumburiga do have a similar amount of rainfall over the whole measuring period, however in figure 9 it is seen that there are differences in the distribution. In Kpaboku the month with the highest amount of rain was August with 309 l/m²

and the rainfall decreased in the following months. Also, compared to the other communities this was the highest amount of rainfall within a month. In Bumburiga as well as in the other communities the highest amount of rain was falling in September. However, in Ando and Bumburiga the differences between August and September are comparably low whereas the differences in the other three communities are distinct. For Nansoni the amount of rainfall was 48 l/m² more in September than in August, in Chere it was even 65 l/m² whereas in Kpaboku the amount in September was 61 l/m² lower compared to August. Despite the low distance between Ando and Kpaboku again clear differences are observed. Especially in August, the difference of the two rainfall amounts was almost 60 l/m². Compared to August and September the recorded value of rainfall in October was appreciably lower in all the five communities. As in the previous month the lowest amount of rain was fallen in Chere with 51 l/m². The highest value was recorded in Kpaboku with 85 l/m². For Ando, Bumburiga and Nansoni there was no notable difference and in all the three communities the amount of rainfall was around 70 l/m². The last rainfall of the season was recorded in Kpaboku on the 25th of October.

In figure 10 the data are cumulatively presented to compare the five communities in a more distinct temporal progress.

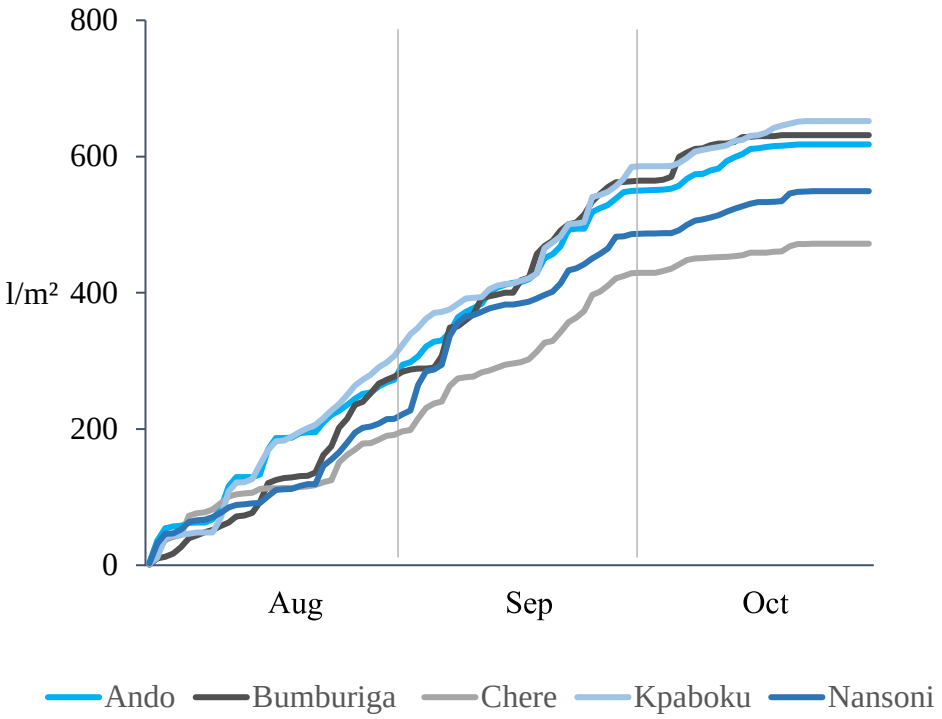

Figure 10: Absolut amount of rainfall in the five research communities from 1st of August until 31st of October 2016 (cumulative)

Here it would be interesting to compare the beginning of the rainy season, whether it starts in all five communities at the same time and with similar intensity. Since the data collection didn´t

start at the beginning of the rainy season only the last two thirds of this rainy season are shown. In the beginning of the data collection there is no considerable distinction between the five communities. Around the first week of August there was a stronger increase in Ando and Kpaboku compared to the other three communities. Subsequently, in these two communities the surge was relatively consistent till September. The quantity in Kpaboku was always a bit higher than in Ando. At the beginning of September, the slope of these two communities was decreasing. The following increase in the middle of September was again in Kpaboku more intense than in Ando, whereby it results in the final difference of quantity. The rainfall in Bumburiga was in the first half of August comparably low. Only between the middle and the end of August as well as in the second week of September the recorded amount of rain was much higher than in the other four communities. Thus, in the middle of September Bumburiga had a similar amount of rainfall as Ando and Kpaboku. The rest of September the slope of Bumburiga was comparable to Kpaboku but its curve flattened faster in October. Chere and Nansoni had a similar amount of rainfall as Ando and Kpaboku at the beginning of the records, which then declined. At the end of August and beginning of September again there was an increase in Nansoni, this was followed by a distinct flatter curve course compared to the previously described courses. The profile of the course of Chere is comparable to the one of Nansoni however it is flatter. The rainy season stopped almost at the same time in all communities. Thus, the last rain was fallen in all five communities between the 21st and the 25th of October.

4.2.1.2 Intense rainfall events

Not only the local and temporal distribution of rainfall is relevant, also its intensity has an effect on agriculture. Therefore, the intensive rainfall events of the five communities will be compared in the following. Table 6 shows the number of intense rainfall events per community and its temporal appearance. An intense rainfall event is here defined as 50 l/m² or more per day.

Table 6: Number of intense rainfall events per community and its temporal appearance. Intense rainfall event is defined as 50 l/m² or more per day

	July	August	September	October	Total
Ando	-	2	-	-	2
Bumburiga	-	2	2	-	4
Chere	1	1	-	-	2
Kpaboku	-	2	1	-	3
Nansoni	2	1	2	-	4

The amount of intense rainfall events range from two in Ando and Chere to five in Nansoni. In Bumburiga, four of these events were recorded and in Kapaboku three. The fact that Kapaboku is the wettest and Chere the driest community does not correspond to the intense rainfall events. Nansoni has the highest amount of intense rainfall events but in total there was less rain than in Ando and Kpaboku. Thus, it can be assumed that in between these events there was a slight amount of rain, and in Ando and Kpaboku the rain events are more regular. It can be also seen that the events in Nansoni are in the beginning of the measuring period and in the end with a break of almost one month. Also in Chere there is a break of more than a month in between these two intense rainfall events. Ando had just two in the first two weeks of August as well as Kpaboku however there was an additional one at the end of September. Bumburiga had four intense rainfall events from beginning of August till the end of September also with a one month break in between. It can be ascertained that the highest amount of intense rainfall events is during the first two and a half weeks of August.

4.2.2 Geo statistics

In order to assess the data in term of their spatial distribution and to verify the reliability of the collected data, they were geostatistical analyzed.

4.2.2.1 Correlation of distance and measurement differences

It has been assumed that, with a heterogeneous rainfall distribution, the measurement difference between stations increases with the distance of these two stations. Thus, it was examined whether there is a correlation or not. In the following figure 11 the distance between two stations is plotted against the difference of the measured amount of rainfall between these two stations. Due to missing values, not all data of the 100 measurement stations could have been used. In Ando and Kpaboku data of two stations in Chere of four and in Bumburiga of 12 were not considered, only in Nansoni there were no missing values in the dataset. Each station that was used was plotted against all the other stations in its community. In four of the five communities, a positive correlation was ascertained, however with a low coefficient of determination. Nansoni was the only community that had a reverse trend line. But also, here the correlation has a coefficient of determination of $r^2=0.035$ which is very low. The graph also shows some outliers in Nansoni with a measurement difference between 200 and 700 l/m². Based on the number of outliers it can be assumed that these were caused by a single measurement station. The majority of the remaining measurement differences is under 100 l/m² and is distributed over the whole area. This implies a homogenous rainfall distribution. With a coefficient of determination of $r^2= 0.04$ Ando has a similarly low correlation. The majority of the

measurement differences is also under 100 l/m² and suggests a uniform rainfall distribution. However, the greatest distance between two measurement stations in Ando is only slightly above one kilometer. For distances, up to two kilometers the differences in Bumburiga do also have a maximum of around 100 l/m². But a correlation between these differences and the distance of the stations is also here with r^2= 0.048 not determinable. The highest value was found in Chere with r^2= 0.12 and Kpaboku with r^2= 0.15, which this is also not a significant correlation. Also, the differences which are mostly under 50 l/m² are quite low regarding to the distances of up to two km in Kpaboku and five km in Chere. Thus, it can be seen that in all five communities the differences of the total amount of rain between two stations is not depending on the distance between these two.

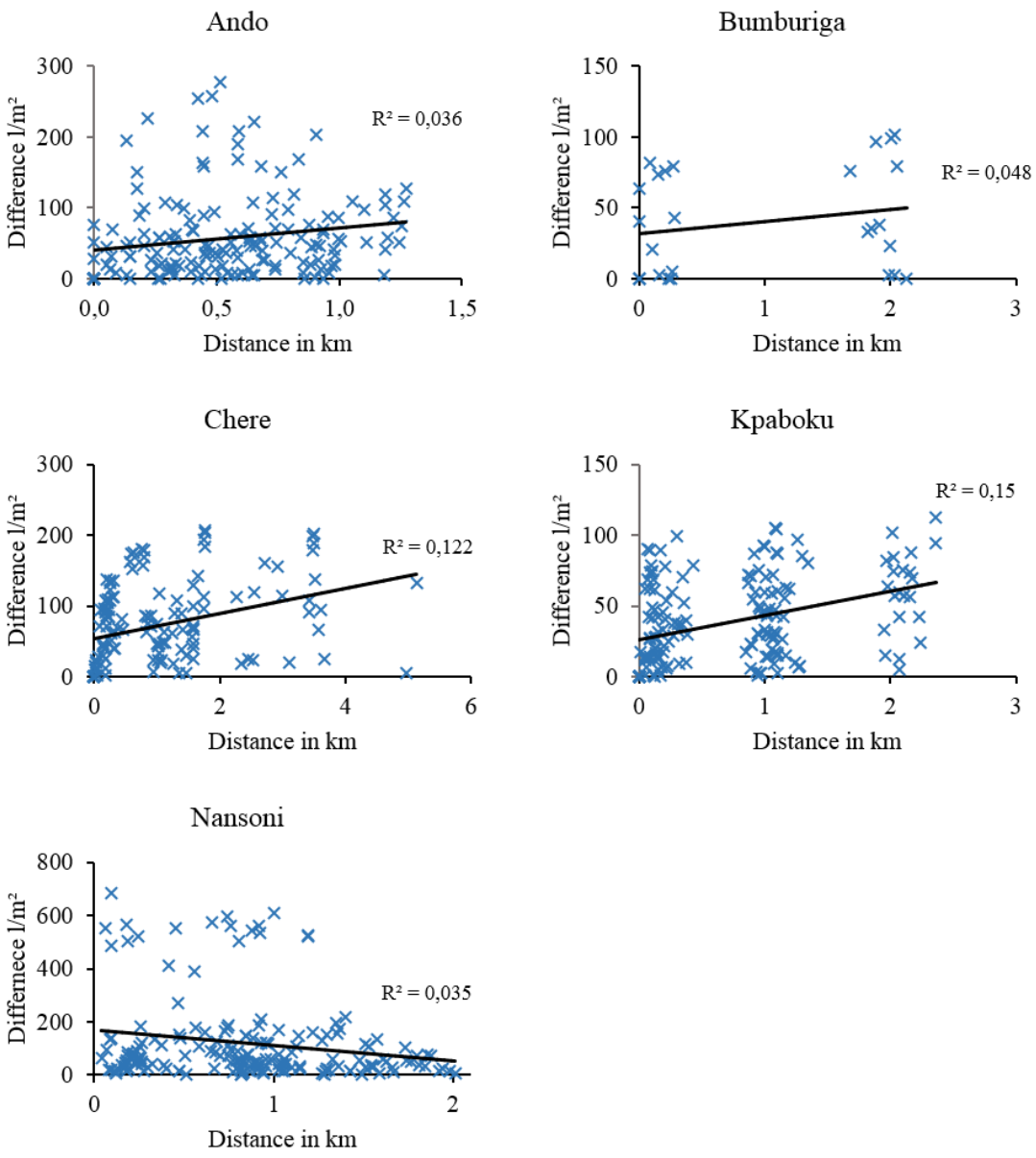

Figure 11: Correlation of the distance between two stations in a community and the difference of total amount of rain between these two stations

4.3 Review of the farming season 2016

As the rainfall data for the farming season 2016 is collected and evaluated it is also interesting to see how the farmers themselves evaluate this season. So, they were questioned, what they think about this season and the amount of rainfall.

In four of the five communities, the women were questioned, and all of them said it was a lot of rain this year. *"It rained heavy this year."* (GM2_N). And compared to last year the rainy season 2016 was better. *"Last year it was a short rainy season, so those who ploughed late couldn't get yield because there was not enough rain."* (GM2_C). *"This year the rain was much*

better than last year but we hope that the rain will stop soon or that it just rains once a week." (GM2_K). But the survey also showed that not all the women are pleased about the amount of rain. Reason for this is that especially in Chere in some fields there was too much rain. "*There was much rain this year, much more than last year. It was too much rain because some fields were flooded."* (GM2_C). In the beginning of the rainy season some fields were already too wet, thus they could not be planted. However, in Ando and Kpaboku the farmers were satisfied. *"It was enough rain, the way it has rained it was like the olden days at our grandparent's time."* (GM2_A). "*It was heavy rain this year but it was not too much, it was good."* (GM2_K). So, it was also interesting to see if they expect different amounts of yield. The result of the survey was that depending on the community the women had different opinions about the expected yield. The women in two (Kpaboku and Nansoni) of the four surveyed communities were satisfied and expect a good yield this year. They said, "*It will be good this year, everyone is happy about the rain this year.*" (GM2_N) and "*[…] we will get good yield.*" (GM2_K). On the contrary, the women in the other two communities said, there will be no good yield. The women in Chere justified the expected bad harvest by the heavy rainfall this year. They said, "*There will be no good yield because of the flood […].", "The […] plants are very small because of too much rain.*" and "*also the roots […] are yellow or almost rotted.*" (GM2_C). Whereas the women in Ando do not see any problem on the amount of rain, they complain the infestation of their fields with the parasitic plant Striga (*Striga bilabiata). "We will not get a good yield because of the disease."* (GM2_A). Summarized it can be said, that most of the questioned farmers are content with the farming season of 2016, and especially that rainfall was not a limiting factor for them.

5. DISCUSSION

The aim of this work was to develop a participatory approach to introduce the rainfall monitoring system in the rural area of North East Ghana as well as to generate rainfall data. In the following this participatory approach is depicted in figure 12 and in the context of the current literature discussed. Furthermore, the monitored rainfall data is compared to the data of the Ghana Meteorological Agency (GMET). Based on this comparison the relevance of the established monitoring stations is assessed and discussed.

5.1 Participatory approach

To develop a participatory approach, the purpose of the involvement of non-scientific stakeholders has to be clarified, as further steps are based on it. In the literature, various reasons are found. Participatory research is described as a method to increase efficiency since it is said that through the involvement of people, the possibility will be increased that these people will accept and support a development or service [Pretty 1995]. Another reason to involve local people can also be the absence of professional researcher or the lack of funding. The term of participation is also used to justify external decisions as well as to develop power and decision-making not only through external organizations [Pretty 1995; Danielsen et al. 2009]. Beside these the most common purposes for participatory research are to empower different groups of people and build up independence as well as to create a sustainable project and awareness for a specific issue [Pretty 1995; Danielsen et al. 2009; Elias et al. 2016].

5.1.1 Purpose of participation

As it is seen in figure 12 these were also the main reasons for a participatory approach in this project. Especially the women in the region should be empowered and an awareness of the issue of climate change and climate adapted agriculture had to be created. Another purpose of the involvement of the local people was to ensure the sustainability of the project. To make a project sustainable it is also important to consider the environment in which it takes place so that the approach is appropriate. Therefore, the involvement of the local communities had the purpose to develop a locally adapted system. It is also important to consider that, as it is describe in White´s classification of participation, the participants do not necessarily have the same purposes to participate [White 1996].

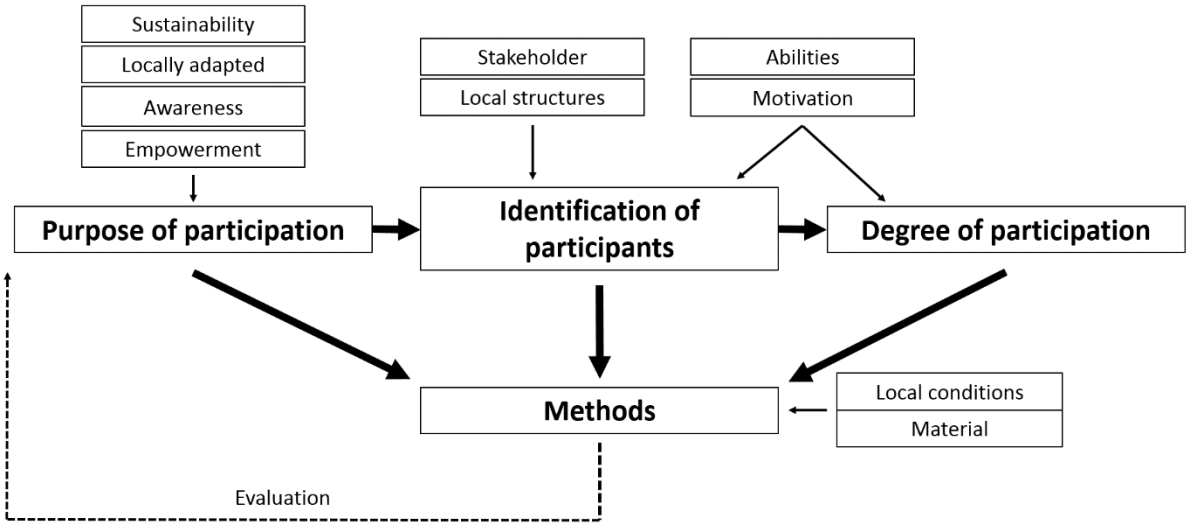

Figure 12: Framework of the participatory approach

In case of this project the sustainability can be seen as the most important aspect since the recording of climatic data only makes sense and provides reliable information if this is done over a longer period. The other aspects, in turn, serve to ensure this sustainability. First of all, the focus is on consciousness building since the comprehension is a requirement for a long-term participation.

The results of the survey showed there is an understanding of the importance of rainfall in the agriculture but the questioned women have a lack of knowledge on climate change as well as on climate adapted agriculture. The women realize the change of the climate and the effect on their agriculture activities, but none of the questioned women were able to describe a possible reaction, except to stop the cultivation of sophisticated crops which have a decreasing yield. Also, in the study of Cobbinahh & Anane is the lack of knowledge in this issue described. It is mentioned that there are adaptions strategies in rural areas of developing countries, but these are mainly focused on the mitigation of short-term impacts rather than on an appropriate strategy in the long-term. The results of this study, which was also located in a rural area of Ghana, show the increasing challenges for farmers due to the changing weather conditions. The common adaptation strategies here are the increase of farm size, the cultivation of less sophisticated cash crops or the change into a non-farming based activity [Cobbinah, Anane 2015]. These strategies cannot be considered as sustainable since in a long term these leads to further problems. This shows the necessity of increased awareness for the changing weather conditions and finally for appropriate adaptation strategies. Besides creating awareness for this

topic, the sustainability of the project can be promoted by a locally adapted technology. The involvement of the locals enables the researcher a better understanding of the role of its innovation in the system. The participation of the stakeholders leads to a better adapted technology as there is an opportunity of exchange, thus facilitating the adaption to the environmental and socio-economic conditions [Martin, Sherington 1997].

To develop a locally adapted rainfall monitoring system, it was also useful to involve the local stakeholders. These are the people who know what materials are available and how to get these. And it is the aim that they work with the monitoring system in future, thus it will be an advantage if they are involved in the development. Furthermore, it increases the likelihood that they will apply it [Michener 1998]. In this study, it was the case that in the previous year a prototype for the monitoring station was devised. This prototype was now improved with the support of the community agents, who had already experience with it. The result of this cooperation was that finally the participants were pleased with the monitoring station and appreciated the simple handling of it. The participation of the locals and their involvement in the process of decision making serves not only for the likelihood of adaption, rather for their empowerment as well as promotion of their independence and the identification with the project. Röling & van de Fliert describe this empowerment as a tool to more sustainable practice. It leads to a greater reliance on the own competence and observation skills as opposed on external expertise and input [Röling, van de Fliert 1994; Bergold, Thomas 2010; Fetterman 2002]. The process of learning seems to be more successful if it is experimental and in cooperation with other stakeholders. This, in turn, encourage the collective process of decision making of stakeholders in the same environment [Röling, van de Fliert 1994]. However, it is also found in the literature, that through the empowerment of the participants it comes to a loss of control and the outsider has no more impact on the project [Michener 1998]. Since this project should be independent in the long term, with the aim that the participants continue on their own responsibility, this fear does not exist. On the contrary, in the best case there should be no external control necessary. So the question arises who will participate to achieve this. Thus, it comes to the next step of a participatory approach.

5.1.2 Identification of participants

For a participatory approach the selection of the participants plays an essential role. To find appropriate people the previous discussed reasons for this approach have to be considered. For example, as in this project especially the female farmers should be empowered, their participation is prerequisite for this. Also the question arises where consciousness-raising is

reasonable to bring a lasting change in the long term. Because of this, in the beginning of the project two options of participants were discussed. The cooperation with the women of the AWG themselves and the involvement of the pupil in the community and the development of a school project. Here important factors which had an impact on the selection of the participants were the local structures and hierarchies. It is often criticised that participatory approaches ignore the structures in place, which can lead to power exploitation. However, the situations of power are not always visible and especially structural power happens behind the back of external participants [Bergold, Thomas 2010; Byrne, Alexander 2006]. The concept of the school project made it clear that an implementation is almost impossible without the support of the local opinion leaders, which makes the work more difficult. Also, the selection of the 20 women in each community was not possible without the codetermination of the community agents. This leads to the fact that they are responsible for the community however it also inhibits the empowerment of the women. The involvement of people can promote, prevent or suppress decisions and actions, depending on the position of the actors in these power structure or the power resources they possess [Bergold, Thomas 2010]. Woking together with the female members of the AWG the low level of participation in decision making became clear. The aim was that the women themselves develop or bring in their own ideas for the rainfall monitoring system. However, during the FGD it was difficult to encourage them to participate on the discussion. Thus, the majority of the women were reluctant to express their own opinions or to bring in their ideas and make suggestions. But in the course of the project a process was seen. Their confidence was strengthened by the fact that they got a task that they should work on independently. This became clear in the final FGD since the women proudly expressed how happy they are that they had the opportunity to learn something new, which they now can explain to others.

But there are further factors that influence the choice of participants. One of the main intentions of participatory research is the creation of a communicative space where all stakeholder are able to explore their daily life and working practice [Bergold, Thomas 2010]. Therefore, it is relevant whom this issue affects and who has through the participation an advantage in his/her daily life. To improve the living condition of social unprivileged groups an active participation in the research process is necessary. Furthermore, for the selection of participants it has to be considered whether the people are able to participate, due to time conditions or personal skills [Bergold, Thomas 2010]. Besides this, an essential factor for participation is the motivation and the willingness of the participants, without these the involvement is not possible. The results of the FGD and the interviews showed that the motivation of the participants was not an inhibiting

factor, as well as time and effort was not problematic. This was reasoned due to the fact that the task itself is not time consuming and the monitoring stations were also positioned as close as possible to the houses. In the literature, the time is often described as the limiting factor for participatory research. And especially the women in developing countries have a lack of time [Byrne, Alexander 2006]. Again, the participation was voluntary, which suggests a motivation to participate.

An inhibiting factor was rather the abilities of the women. So, the main challenge for them was to understand and correctly implement the methodology of the data documentation. However, this problem was able to be solved through a more intense supervision. This as well as the reference community in Bumburiga showed the importance of a competent supervisor, especially in the beginning of a project. In participator research, often the capacity of the participants has to be developed during the process. For example, like in this case a training for the data collection had to take place [Byrne, Alexander 2006]. To ensure the supervision and to cede the responsibility of the project step-by-step to the locals, supervisors had to be identified in the communities. Also for this selection the previous discussed factors were leading.

5.1.3 Degree of participation

The motivation as well as the abilities of the participants does not only influence the selection of them but also the degree of their participation. The determination of the degree of participation is the next step in this participatory approach. Here it has to be taken into account that this is not a fixed decision as the degree of participation will be developed and changed during the course of the project. In the practices movements in the degree of participation take place in different stages of the research and for different purpose [Cornwall, Jewkes 1995; Byrne, Alexander 2006]. In the literature, the participatory approaches are often characterized through the degree of participation. It goes from ‘shallow’ participation which means that the researcher has the control of the whole project, to a ‘deep’ participation. With its increasing intensity the control will be provided to the participants which are influenced by the research [Cornwall, Jewkes 1995]. With the scope of this range Biggs describes in the field of agriculture four types of participation.

1. Contractual – people are contracted in a project to participate in surveys and experiments.
2. Consultative – people are asked for their opinion and are consulted before interventions are made.

3. Collaborative – researcher and locals work together in a project which is designed, initiated and managed by the researcher.
4. Collegiate – researcher and locals are working together as colleagues with different skills and offers, in process of mutual learning where the locals have control [Cornwall, Jewkes 1995].

In this project the participants should be involved in the development of the project as well as in the decision making process from the beginning, however with support and instruction of the researcher. In the course of the project those participating should become more and more independent so that in the long term the involvement of the researcher is not crucial.

The types of participation are determined through the willingness of the researcher to involve the locals, which is dependent on the purpose of the participatory approach. The degree of participation is also dependent on the participants themselves, on their motivation and abilities. The motivation can occur through the interest of the participants on the topic and that they are able to see the opportunity to solve a problem which is concerning to them. Especially resource-poor people can be motivated to participate in needs-related research and exploring solutions for those problems [Martin, Sherington 1997; Danielsen et al. 2009]. Additionally, the organisations or researchers often create incentives to motivate the locals to participate. Thus, participatory approaches raise the expectations of the participants that they are well rewarded in some way. It is hard to control these expectations and another problem with these material incentives, is that these incentives create dependence and once the they are ceased the participation is also terminated [Pretty 1995; Byrne, Alexander 2006].

In this project the theme of motivation was discussed with the participants. The result of this discussion was that the participants see motivation as an essential element of any work. They saw the motivation in the benefit that they will have through this research. They can use the generated data to improve their farming activities in future. Nevertheless, they said that any further incentive is appreciated and could improve the motivation to participate. Thus, the women received an allowance, for the interviews and FGD in form of biscuits and beverages. And also, the pens and exercise books they got for the data collection served as motivation. In the course of the project the motivation of the women increased due to the fact that they learned something new and they realized that their work is appreciated. At the end of the trial period these was supported through the information sign, which was also seen as an award for their great work. Furthermore, the presentation and discussion of the collected data was important as the participants wanted to see the results of their work. This is also a fundamental aspect of

participatory research: the commitment to give the results of the project back to the participants [Minkler 2004]. For the presentation of the data it has to be considered that these will be also in an appropriate form for the participants. Thus, a scientific presentation is not always useful. A visualisation of the data could improve the understanding of the results [Bergold, Thomas 2012]. For example, the rainfall data was presented to the women in form of a bar chart to show the differences in the course over time. The availability and use of the data is also a factor that characterizes the degree of participation. The question is if the participants are just involved to generate the data or whether they get access to these and have a use [Danielsen et al. 2009]. This will be also an important factor in the future of this project to maintain the motivation.

However, even if the motivation of the participant is great, the abilities of them can still be an inhibiting factor. Thus, it is also crucial to determine the degree of participation. For example, the participants can only take part in the decision-making process if they have sufficient knowledge about the topic. Or as it was in this project, the questions arise if the women are able to monitor the rainfall data autonomously. However, as already mentioned, the initial state does not have to be fixed. The capacities and abilities of the participants can be developed and elaborated in the course of the project and thus also change the degree of participation. To achieve a higher degree of involvement it is necessary to adapt the methodology, for example the data collection, to the abilities of the participants [Bergold, Thomas 2010]. Also in the first FGD the theme of rainfall monitoring was introduced to the women and a potential methodology was demonstrated, after this the women were already able to point out possible problems or suggestions for improvement. Also, for the data collection they had concerns that they are not able to fulfil this task due to the fact that they cannot write. But through the adjustment of the method of documentation and through personal training this was no longer a problem. All of these discussed steps of the participatory approach ultimately lead to the last step of this approach, the actual methodology of the project as well as to the methods for the interaction with the participants.

5.1.4 Methodology

As it was already presented the methods for the interaction with the women were FGDs and interviews. Since the participants were already used to it from previous projects these methods seemed to be suitable to get general information about the situation as well as to identify individual needs. And the rainfall monitoring method was developed in cooperation with the participants.

Studies indicated that the flexibility and the adaptation of the methods are of great importance and a mixture of participatory and conventional technics could lead to achievement of the objectives. It is not the method itself which ensures the success, but the essential role of the institution and the protagonists by whom these method is used [Biggs, Smith 1998].

So, the methodology to monitor the rainfall is based on the abilities of the participants and the materials that were readily available. Also, the techniques of discussion and presentations were meant for the participants and thus showed obvious achievements. The executed interviews were semi-structured. Preliminary central questions were formulated but during the interview questions adhered to the individual's needs. For participants with a greater deficit in the data collection the focus of the interview was set there. The central theme of the interview with a participant who had fewer difficulties was the consciousness building. In all these interviews, it became clear that the women were proud to learn a skill, which is not common within the community, and that they appreciate to help others of the group if they do have problems. This fact was used in the final FGD to verify the achieved knowledge. Thus, the women were asked to imagine, that an outsider of the project is asking them what they do with this construction in front of their house and why, and they should explain the work they are doing. The women were highly motivated to explain what they are doing to show what they have learned.

Another method which was used was visualization. Visualization is used to clarify processes like the further steps in the project as well as to present the collected rainfall data. Visualization clarifies more, which would not be possible through verbal communication [Cornwall, Jewkes 1995]. Thus, the feedback for the visual representation of the further steps was particularly high. All the participants said that through this explanation they now understood how it continues in the future and that they can see that the work they are doing is not in vain, rather the data are used. Additionally, diagrams are a common method for the visualization of information, so the rainfall data were presented in a bar chart [Chambers 1997; Cornwall, Jewkes 1995]. Through this visual representation of the data one could clearly show the differences of the precipitation to the women, which would not be possible by the representation of the numerical data.

A participatory approach can only be successful when the methods are adapted to the needs, capacity and aims of the participants. Furthermore, it is important to evaluate the approach, through verification if the previous objectives of the participation have been achieved or will be.

5.1.5 Evaluation

A participatory approach is not a guarantee for a successful project. A problem of participation is if a too great trust on its effectivity leads to an executive and uncritical use [Biggs, Smith 1998]. Therefore, it is important to evaluate the approach and the applied methods. In this project, it is questioned if this approach leads to a locally adapted monitoring system, whether the participating women were empowered through this work, to what extent a consciousness raising took place and finally whether a sustained success is to be expected. If these criteria are met, it can be seen as a successful implementation.

As it was described in the section above, the methods of the project were adapted to the needs of the participating women as well as on the local conditions. Furthermore, only local materials were used which are available at any time. Thus, it can be assumed that the system is locally adapted, which was one of the objectives of the participatory approach.

To determine if the women are empowered through their participation in the project, first of all the definition of empowerment has to be clarified. The technical definition of empowerment most often uses terms like options, choice, control and power [Narayan-Parker 2005]. Regarding these the aim of empowerment can be seen as achieved. Thus, the women had the option to participate or not, were promoted and had the power to make choices for the development of the project, and controlled the rainfall monitoring. Chamberlin & Schene see the key elements of empowerment in the access to information, ability to make choices, assertiveness, and self-esteem [Chamberlin, Schene 1997]. This point can be also considered fulfilled. The women had access to all information concerning the project, they were trained and enlightened thus they were able to make decisions on the project. The surveys also made clear that the women are proud to participate on this project and that they are happy to have the opportunity to learn something, as a woman. This certainly contributes to the increase of self-confidence. Whether the participation has increased their assertiveness was not possible to assess out of the compiled data. Narayan-Parker says more, that empowerment means to strengthen the capacity of the individual or groups to make purposeful decisions and that their capacities lead to desired actions and results [Narayan-Parker 2005]. Similar to these is found in the study of Kabeer, she says empowerment is “the expression in people`s ability to make strategic life choices in a context where this ability was previously denied to them” [Kabeer 1999]. Concerning the project the women are skilled so that they are able to make project-related decisions which lead to the desired result of the rainfall monitoring. Furthermore, it is the objective of this project that in the long term a fundamental comprehension for rainfall and

its impact on the agriculture will be developed, which will qualify the women to make strategic decisions regarding their agricultural activities. To what extent this will be possible cannot be assessed at the current time. And it´s also sure, that this will not only by achieved through the collection of rainfall data. Further discussion and workshops by the responsible people of the NGO are necessary. Additionally, the literature review shows the complexity of the evaluation of empowerment which can be not done on the basis of single factors and facts [Narayan-Parker 2005; Kabeer 1999; Chamberlin, Schene 1997; Malhotra, Schuler 2005]. The operational measurement of empowerment is particularly difficult due to its ambiguity and elusiveness. It is argued that empowerment does not exist as an individual, but rather is the reflection and representation of other things [Narayan-Parker 2005]. Thus, a detailed evaluation of these would not have been possible in the scope of this work.

In every meeting with the participants the comprehension of climate and climate variability was discussed and tried to improve it step by step. The results of these discussions show that they are aware of the variability of the climate and have a logical comprehension that due to this a permanent documentation of the weather is reasonable. But a scientific knowledge does not exist and it was proved to be difficult to impart it. An interesting result from a similar study of Cobbinah & Anane was that locals in another region of Ghana linked the changing weather conditions with issues of local culture and said that the `gods of the land` are the reason for unpredictable rainfall [Cobbinah, Anane 2015]. In the discussion and interviews of this project these issues did not arise, however during the stay and the interaction with the locals it was experienced that the cultural belief has a major impact on their activities. Thus, this has to be considered in the cooperation with local people. In the individual interviews, it was attempted to explain the difference of weather and climate in a simple way. Despite great interest it was hard for them to understand. This is explained by the fact that there is no prior knowledge and the time for the workshop was limited. But it was also not the objective to convey a broad scientific knowledge to the participants. This would not have been possible in the context of this project and is even not necessary. More importantly the framers learn to perceive, and assess the climate conditions to be able to react on these. This is not learned through explanations, rather through experience. Thus, the objective was that the rainfall monitoring will become a part of their daily life to perceive the variety and development of it. Also, Leeuwis describes the process of learning as a part of our daily life. Everyone obtains everyday feedback from the environment which leads to insights and this in turns to an adaptation [Leeuwis 2013]. Thus, climate adaptation has to take place where climate change is perceived [McNamara, Buggy 2016]. Or in other words, climate adaptation takes place if the change is observed. The

access to climate information can increase the awareness of climate change and thus support the adoption of climate adaptation strategies [Jalón et al. 2015]. And this perception should be promoted through the daily monitoring of the rainfall. Here also the local organisations and the government play a role. They are also contributing to raise awareness and can act as model. A discussion with the director of the Ministry of Food and Agriculture (MoFA) in Chereponi revealed that they have a professional rain gauge in Chereponi which they received from a development aid agency. However, there are only data for the first year (2015), since afterwards no one felt responsible for it anymore. Such a manner of course gives a bad impression to the local community and could jeopardize a long-term participation on this project.

The sustainability of this project and therefore this approach will only be apparent in the future. The fact that the monitoring was continued after the departure of the researcher is a positive sign. A determining factor, however, will be whether the monitoring will be also continued after the interruption through the dry season.

5.2 Reference Community

As this project should be continued without the attendance of the researcher, the community Bumburiga, which was difficult to reach, was seen as a reference community, to evaluate whether the data collection can be expected without the attendance of the researcher. The results show that until the end of the trial period in Bumburiga only 65% of the women have data collected, whereas in the other four communities, with a more intense supervision, 100% of the data was received. Since the task of data collection was new to all the women, one reason could have been that some of them are over challenged with it and had a problem with the correct documentation. One of the five characteristics that determine the rate of adoption of an innovation is the complexity. How difficult an innovation is to understand or to use has a great impact on the fact whether an individual will adopt it or not [Rogers 2002]. Thus, an adequate introduction and supervision especially in the beginning can be of great importance to reduce these difficulties. At the beginning of the project two of the four other communities also had missing records. Complete records from the beginning of the project were the communities Nansoni and Kpaboku. One reason was, that the community agent in Nansoni is highly motivated and thus the women had a perfect supervision. The other two communities with missing records were Ando and Chere. Here the individual interviews with the women showed that the missing or wrong records are reasoned due to the fact that the women didn´t understand the explanation by the translator how to record the data. Therefore, the women received an additional briefing in the data documentation. As a result, the data were then recorded correctly

by all the women. Furthermore, the results show that a community with a direct connection to Chereponi as Ando and Kpaboku had less missing records than for example the more distant community Chere. This suggests a better understanding for the data collection. This impression was also mediated in the personal interaction with the women. A reason for this could be the better opportunity for exchange with other participants or the better contact of the community agents to the leaders of the AWG. The interaction with other stakeholders has also a great influence on the decision making process, often more than the interaction with an expert or his/her advice [Rogers 2002]. After the two-month trial period without any supervision, the women in Bumburiga received another personal instruction from the community agent. This leads to that the following month 100% of the records being received. This suggests that the reason for the missing records were the lack of understanding and not the motivation. This show to reach a 100% successful implementation of a project, supervision especially in the beginning, is indispensable. Since small problems can be solved easily, also solutions for greater challenges can be found through interaction. In future, it will be seen whether supervision by the community agents and the contact persons will be sufficient and ensure a long-term data collection.

5.3 Rainfall data

In the following chapter the collected rainfall data will be evaluated and discussed to assess the relevance of the established monitoring stations. For this the data, will be compared with data of the Ghana Meteorological Agency (GMET), additionally, the comparison of the five communities will be discussed as well as well as the data of the 20 measurement stations within a community.

5.3.1 Comparison to meteorological data set

The GMET has 19 measurement stations distributed in Ghana and do have a data pool from earliest 1944 till today. Out of these, the closest monitoring station to Chereponi is the one in Yendi, with a distance of around 90 km. Data from 1950 to today is available. Thus, the collected data can be compared with the data of the year 2016 as well as the year can be compared to previous years.

In figure 13 the data of 2016 from Yendi are cumulatively presented. This shows a total amount of rainfall of almost 1400mm in the year. As in this project the data collection started at the end of July a direct comparison is difficult. However, having a look at the period from August till November (marked by the red strokes on the ordinate) the total amount here is around 650mm. This is comparable to the amount in the five communities. It is above the values measured in

the communities but in case of Kpaboku with 644mm merely nominal. The profile and the slope is also comparable to those of Ando, Bumburiga and Kpaboku.

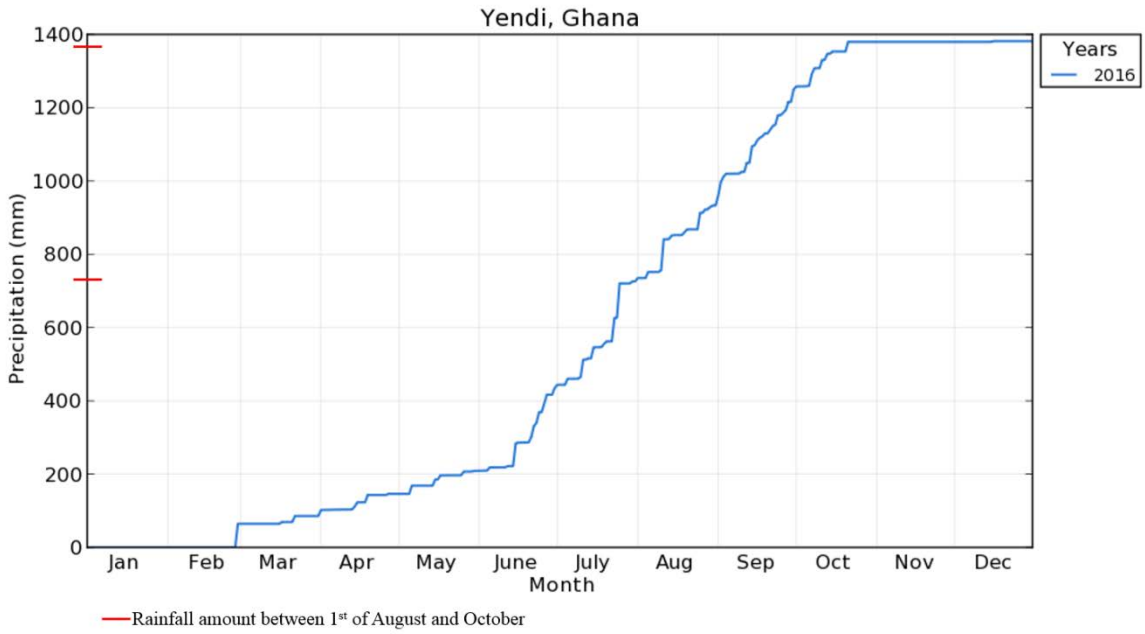

Figure 13: cumulative rainfall data 2016 measurement station Yendi, Ghana [Ghana Meteorological Agency (GMET) 2017]

This graph also shows that from the beginning of the year till mid-June the amount of rainfall is low. Thus, the main rainy season starts in June and goes until October. For a better comparison, the specific months have to be considered. Therefore figure 14 shows the total monthly amount of rainfall of the station in Yendi. As this data is presented in a Boxplot design the data is additionally classified in the timeframe from 1950 till now.

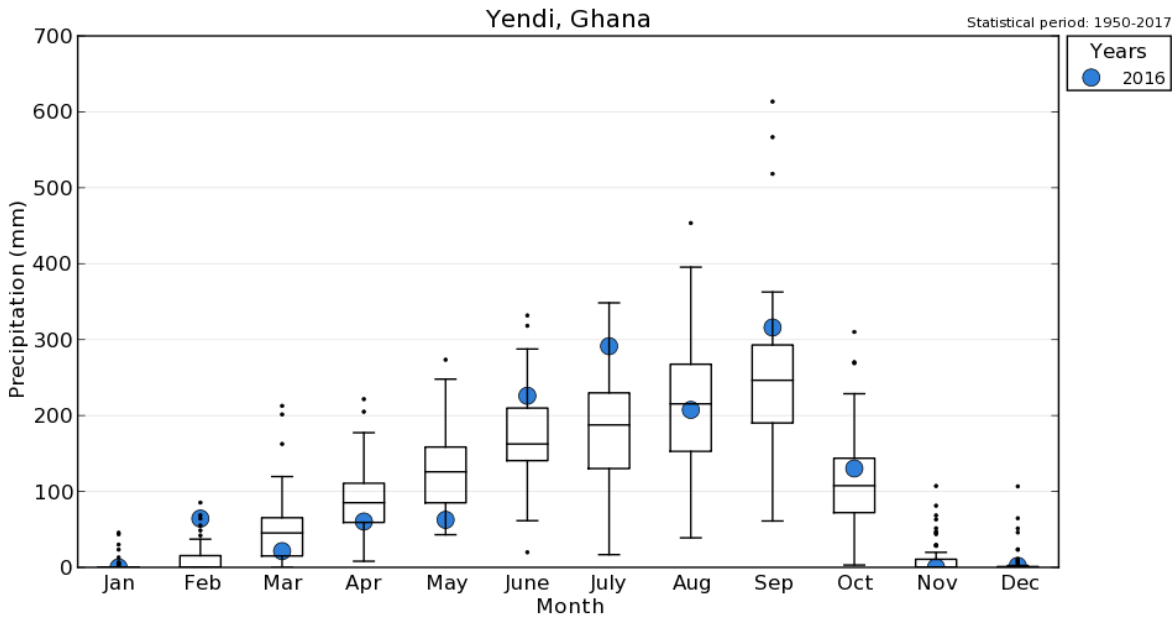

Figure 14: Absolut rainfall per month, measurement station Yendi, Ghana [Ghana Meteorological Agency (GMET) 2017]

Here it can be seen, that September was with around 320mm, the month with the highest amount of rain. Except of Kpaboku this was also the case in the communities however, the amount of rainfall was lower than 300mm. Looking at the amount of rainfall in August, in three of the five communities the amount of rainfall was between 50 and 100mm higher than in Yendi, whereas Nansoni has almost the same amount. In October, all the five communities have a lower amount of rainfall than Yendi. This comparison shows that the difference of the absolute amount of rainfall, except of Chere and Nansoni is relatively low, whereas the monthly distribution is barely comparable. Interestingly here, the differences in between the communities are partially as clear as the differences to Yendi. Thus, the distance cannot determine the precipitation differences. Although, there are some differences in the collected data of this project and the data of the monitoring station in Yendi, to get an overview of the rainfall development in this region the Yendi data are representative. Thus, in the following these data are used to have a look on the year 2016 in relation to previous years.

Comparing the year 2016 to previous years the months during the main rainy season were significantly wetter than the average, with the exception of August where the amount of rain is almost exactly on the median. June, July and, September are above the middle 50% of the data pool. In figure 15 this is also shown in a cumulative presentation of the data with the 10th to 90th percentiles. This allows the classification of the year in relation to the last 66 years.

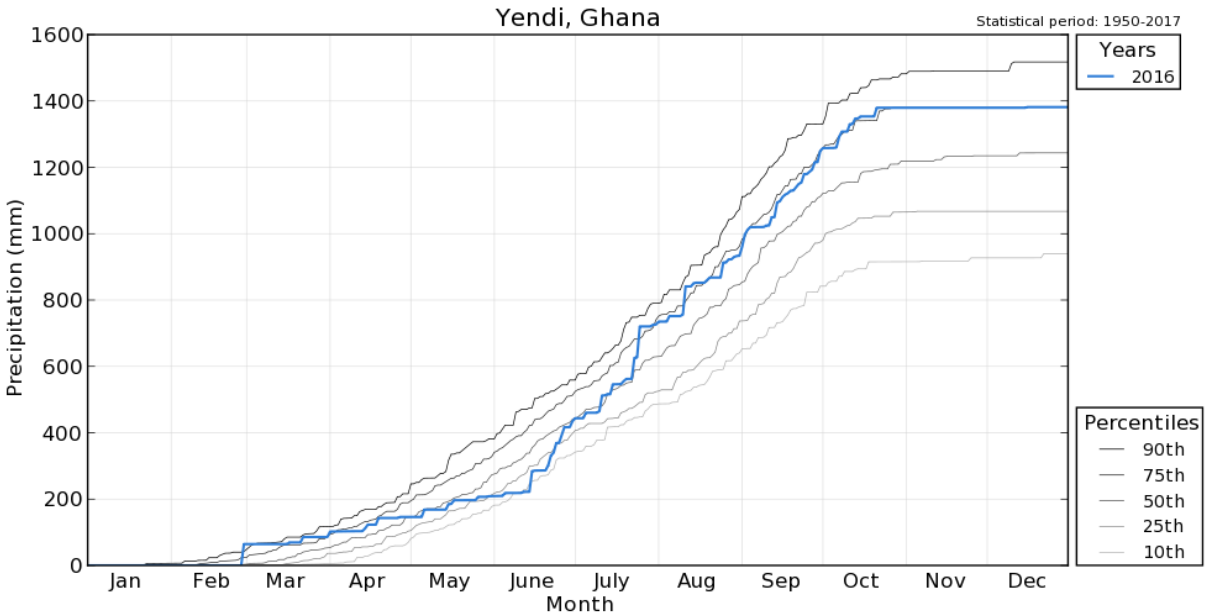

Figure 15: cumulative rainfall data 2016 and percentiles (1950-2017) measurement station Yendi, Ghana [Ghana Meteorological Agency (GMET) 2017]

The end of this curve shows that the amount of rain in 2016 was relatively high as it lies in the 75th percentile of the data pool, which means only 25% of the previous years had the same or a higher amount of rain. Interestingly, here at the beginning of the year, (excluding end of February) the rainfall was relatively low, with the result that mid-June the total rainfall was on the 10th percentile and so lower than 90% of the data pool. This shows that the main rainy season has started later and was then more intense. To see if 2016 was merely a temporal occurrence, in figure 16 the year 2016 is presented with the percentiles of the past ten years.

Figure 16 shows that the total amount of rainfall in 2016 that confirms the average of the past ten years is exactly on the 50th percentile. Thus, 2016 cannot be considered as an outlier as for example the previous year 2015 which is also shown in figure 16. The 50th percentile of the last 10 years had a total amount of 1400mm per year whereas the 50th percentile of the last 66 years is at around 1200mm per year. This suggests that the total amount of rain is increasing. This assumption agrees with other observations in West Africa, which also indicates the increase of the annual rainfall since 1990 [Williams et al. 2017]. Mertzl et al. however, describe the problem that there is no clear opinion in the literature about this. Thus, beside the sources which mention an increase of annual rainfall in West Africa, there are others are talking about a decline [Mertz et al. 2009].

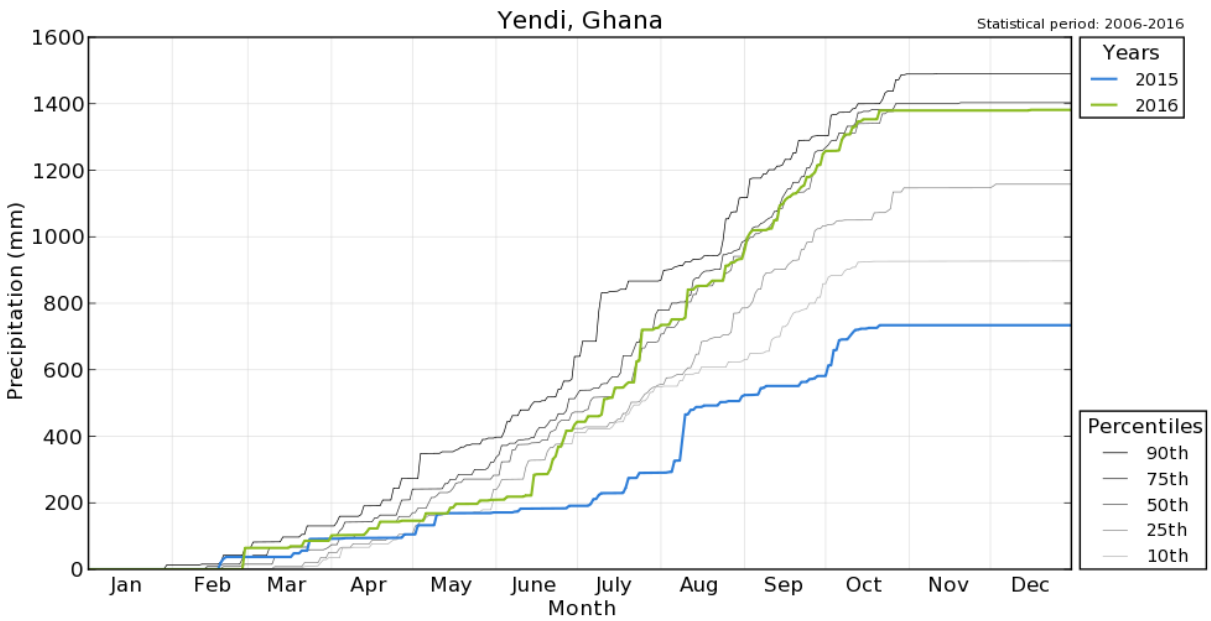

Figure 16: cumulative rainfall data 2016 and 2015 with percentiles (2006–2016) measurement station Yendi, Ghana [Ghana Meteorological Agency (GMET) 2017]

A major mistake is the general statement about the rainfall development in West Africa as there are regional variabilities [Owusu, Waylen 2009]. Yet, there is not only an uncertainty about the annual rainfall, also the determination about the beginning of the rainy season becomes increasingly difficult [Laux et al. 2008]. Figure 15 shows that in the past 67 years the rainy season mostly has started at the beginning of March and had a continuous rainfall. Although in figure 16, the trend is seen that the rainy season starts earlier, around February and initially only increases slightly. This is also seen in 2016 as well as in 2015. A reliable estimation of the beginning of the rainy season is of great importance for the farmers to determine an optimal sowing date [Laux et al. 2008]. The unpredictability of the onset of the rainy season is one of the largest concerns of farmers [Derbile, File 2016; Dickinson et al. 2016; Eguavoen 2012]. As the results of the FGDs have showed, farmers use the beginning of the rainy season to plan their farming activities. Thus, an early start of the rainy season with a following decrease of rainfall can have a serious impact on their farming. This shows the importance of a complete data pool of rainfall data to monitor and assess the change of the rainy season. Of additional importance here is to know if the start of the rainy season is spatially different. Since the rainfall monitoring in the five communities didn`t start with the rainy season this comparison cannot be made. Therefore, the more important it is to start the recording in future with the beginning of the season. Generally a high spatial and temporal variability of rainfall amount and a non-uniformity has to be assumed [Laux et al. 2008]. The question was in which scope variability must be expected. So, whether in each of the five communities a monitoring station is necessary, or would one central station be sufficient. As the results of the rainy season 2016 have showed,

there are indeed differences in the amount and the temporal distribution of rainfall in the five communities. As there are statistically significant differences, it is justified to have measurement stations in all five communities. For a rough estimation, the station in Yendi would be sufficient as the differences in between the communities are comparable to the differences between the communities and Yendi. Now the question arises whether 20 measurement station per community are necessary. The result of the geo-statistical analysis show that the difference of the amount of rainfall is not depending on the location of the station. Thus, it can be assumed that the rainfall distribution in the communities is relatively homogeneous and the few distinct differences of rainfall amount between any two stations are caused by individual measuring errors. So, a smaller number of measurement station would be suffice. To determine the optimal number of measurement stations per community further data would be needed for a temporal independent comparison of the measurement stations.

5.3.2 Review of the season by farmers

Since it was an aim of this project to strengthen the farmer's perception of the climate, they were asked in the final FGD how they assessed the rainy season of 2016. This should, among other things, show whether the assessment of the farmers is consistent with the measured data. Cobbinah and Anane described in their study that the trend of changing weather conditions which were mentioned by the locals is supported by the meteorological data [Cobbinah, Anane 2015]. But there are also other studies were this was not confirmed [Eguavoen 2012]. The results of the survey in four of the five communities show that all of the participants describe the rainy season 2016 as extremely wet. Looking at the year 2016 in the context of a longer period this can be confirmed by the measured data as seen in figure 15. But, it can be observed that 2016 is an average year in the last decade. The reason for the judgment as a rainy year can be the direct comparison to previous year which was, as it is also seen in figure 16, extremely dry. All the participants of the survey said that this year (2016) was distinctly better than the last year. However, the survey also showed that the farmers generally assume that nowadays it rains less than in the past. They describe the rain in 2016 was like the "olden days", in the time of their grandparents. But, as the data of the measurement station in Yendi show, a decrease in the amount of rain cannot be detected.

The results also show that the rainy season is evaluated differently depending on the community. As contrasted with the other communities, the participants in Chere said that they are not satisfied with the rainy season this year, since it was too much rain. They complained that some of their fields were flooded or some were too wet and thus not able to be planted.

Interesting to see is that Chere had less rainfall than all the other communities. Thus, the women in the other communities were also asked if they think there was too much rain, or whether they had problems with flooded fields. But this was denied by all of them. There may be various reasons for this. One significant factor for the soil moisture is, of course, the soil itself. Different soil types and/or characteristics of the soil, like the structure or the void space have an impact on the infiltration of the water. But also the relief can influence this [Löhmannsröben 2002; Giertz 2004]. So, there can be despite a decreased precipitation in Chere a lower infiltration and thus higher soil moisture compared to the other communities. Additionally, of course, even in the case of a lower overall precipitation, the quantity of rain per rainfall event could be higher which can also lead to temporarily lower infiltration [Giertz 2004]. However, the result of the intense rainfall events show no exception in Chere compared to the others. Further investigations are necessary for an actual explanation.

6 CONCLUSION

Based on the collected rainfall data and its comparison with the data of the measurement station in Yendi as well as the comparison in between the five communities, it can be concluded that rainfall measurement stations in each community are justified, as it provides useful information about the different rainfall distribution in this region.

This study also showed that there are significant deficits among female farmers about the understanding of climate change and an adaptation on this. Thus, it can be concluded, to ensure a successful and sustainable agriculture for these women continued consciousness-raising is indispensable. Furthermore, working with the locals made it clear that the empowerment of the women, which is one of the major objectives of the interdisciplinary project, is still at the beginning. Participation of the women on this study was not possible without the involvement of the male leaders of the communities. However, working with the women also showed that through their involvement and the transmission of responsibility their confidence was built up. Thus, their involvement and the opportunity for them to make decisions is a step in the right direction. The major challenge on this participatory approach was to adapt the task on the abilities of the participants, or on the other side, to train the participants in a way that they are able to fulfil the work. However, the results of the study show that through a close cooperation and supervision these challenges can be overcome. Thus, it can be said that for the implementation of an innovation, it is particularly useful to keep the group of the participants in the beginning smaller in order to be able to provide an intensive supervision. If the innovation is implemented successfully in the first place, the extension to other stakeholders is easier and takes place partly by the independent exchange.

Further research based on this study could be the observation whether the approach leads to a long-term establishment of the system, and if not, for what reasons. Since the empowerment of the women through this project was not able to evaluate this could be an issue of further research. Additionally, it would be also interesting to observe whether a bottom-up approach increases the likelihood of the adoption of climate adaptation strategies in the agriculture of developing countries. In the course of this project further parameters have to be determined in order to develop an adaptation strategy for rainfall, especially data about the soil properties are required.

7 REFERENCES

Publication bibliography

Alexander, Clarence; Bynum, Nora; Johnson, Elizabeth; King, Ursula; Mustonen, Tero; Neofotis, Peter et al. (2011): Linking indigenous and scientific knowledge of climate change. In *BioScience* 61 (6), pp. 477–484.

Barreteau, Olivier; Bots, Pieter; Daniell, Katherine (2010): A framework for clarifying "participation" in participatory research to prevent its rejection for the wrong reasons. In *Ecology and Society* 15 (2).

Bergold, J.; Thomas, S. (2010): Partizipative Forschung. In : Handbuch Qualitative Forschung in der Psychologie: Springer, pp. 333–344.

Bergold, J.; Thomas, S. (Eds.) (2012): Partizipative Forschungsmethoden: Ein methodischer Ansatz in Bewegung. Forum: Qualitative Social Research.Deutschland. Vol. 13. No. 1: Deutschland (13).

Biggs, Stephen; Smith, Grant (1998): Beyond methodologies: coalition-building for participatory technology development. In *World development* 26 (2), pp. 239–248.

Byrne, E.; Alexander, P. M. (Eds.) (2006): Questions of ethics: Participatory information systems research in community settings: South African Institute for Computer Scientists and Information Technologists.

Chamberlin, Judi; Schene, Aart H. (1997): A working definition of empowerment. In *Psychiatric Rehabilitation Journal* 20, pp. 43–46.

Chambers, R. (1997): Shortcut and participatory methods for gaining social information for projects. In *Sustainable development: social organization, institutional arrangements and rural development* 6, pp. 177–208.

Chambers, Robert (1994): Participatory rural appraisal (PRA): analysis of experience. In *World development* 22 (9), pp. 1253–1268.

Cobbinah, Patrick Brandful; Anane, George Kwadwo (2015): Climate change adaptation in rural Ghana. Indigenous perceptions and strategies. In *Climate and Development* 8 (2), pp. 169–178. DOI: 10.1080/17565529.2015.1034228.

Cornwall, Andrea; Jewkes, Rachel (1995): What is participatory research? In *Social science & medicine* 41 (12), pp. 1667–1676.

Danielsen, Finn; Burgess, Neil D.; Balmford, Andrew; Donald, Paul F.; Funder, Mikkel; Jones, Julia P. G. et al. (2009): Local participation in natural resource monitoring: a characterization of approaches. In *Conservation Biology* 23 (1), pp. 31–42.

Derbile, Emmanuel K.; File, Dramani J. M. (2016): Community risk assessment of rainfall variability under rain-fed agriculture: the potential role of local knowledge in Ghana. In *Ghana Journal of Development Studies* 13 (2), pp. 66–83.

Dickinson, Katherine L.; Monaghan, Andrew J.; Rivera, Isaac J.; Hu, Leiqiu; Kanyomse, Ernest; Alirigia, Rex et al. (2016): Changing weather and climate in Northern Ghana: comparison of local perceptions with meteorological and land cover data. In *Regional Environmental Change*, pp. 1–14.

Eguavoen, Irit (2012): Blessing and destruction: Climate change and trajectories of blame in Northern Ghana= Bénédiction et destruction. ZEF Working Paper Series.

Elias, Marlène; Jalonen, Riina; Fernandez, Maria; Grosse, Alessandra (2016): Gender-responsive participatory research for social learning and sustainable forest management. In *Forests, Trees and Livelihoods*, pp. 1–12.

Farrington, John; Martin, Adrienne M. (1988): Farmer participatory research: A review of concepts and recent fieldwork. In *Agricultural Administration and Extension* 29 (4), pp. 247–264.

Fetterman, David M. (2002): Empowerment Evaluation: Building Communities of Practice and a Culture of Learning. In *American Journal of Community Psychology* 30 (1), pp. 89–102.

Food and Agriculture Organization of the United Nations (FAO) (2016): AQUASTAT - FAO's Information System on Water and Agriculture. Available online at http://www.fao.org/nr/water/aquastat/countries_regions/GHA/, checked on 4/18/2017.

Fosu-Mensah, Benedicta Y.; Vlek, Paul L. G.; MacCarthy, Dilys S. (2012): Farmers' perception and adaptation to climate change: a case study of Sekyedumase district in Ghana. In *Environment, Development and Sustainability* 14 (4), pp. 495–505.

Ghana Meteorological Agency (GMET) (2017): Ghana Rainwatch Reports. Edited by Board of Regents of the University of Oklahoma. Available online at http://www.rainwatch-africa.org/rainwatch/#country=GHA, checked on 4/11/2017.

Giertz, Simone: Analyse der hydrologischen Prozesse in den sub-humiden Tropen Westafrikas unter besonderer Berücksichtigung der Landnutzung am Beispiel des Aguima-Einzugsgebietes in Benin, checked on 4/25/2016.

Hupfer, Peter; Kuttler, Wilhelm; Chmielewski, Frank-Michael; Pethe, Hermann (2005): Witterung und Klima. Eine Einführung in die Meteorologie und Klimatologie. 11., überarbeitete und erweiterte Auflage. Wiesbaden, s.l.: Vieweg+Teubner Verlag. Available online at http://dx.doi.org/10.1007/978-3-322-96749-7.

Jalón, Silvestre García de; Silvestri, Silvia; Granados, Alfredo; Iglesias, Ana (2015): Behavioural barriers in response to climate change in agricultural communities: an example from Kenya. In *Regional Environmental Change* 15 (5), pp. 851–865.

Johnson, Nancy L.; Lilja, Nina; Ashby, Jacqueline A. (2003): Measuring the impact of user participation in agricultural and natural resource management research. In *Agricultural systems* 78 (2), pp. 287–306, checked on 1/16/2017.

Kabeer, Naila (1999): Resources, agency, achievements: Reflections on the measurement of women's empowerment. In *Development and change* 30 (3), pp. 435–464.

Köppen, Detloff (2004): Bodenfruchtbarkeit im Agroökosystem. Hamburg: Kovac (Schriftenreihe agrarwissenschaftliche Forschungsergebnisse, 25/2).

Koster, R. D. (2004): Regions of Strong Coupling Between Soil Moisture and Precipitation. In *Science* 305 (5687), pp. 1138–1140. DOI: 10.1126/science.1100217.

Kotir, Julius H. (2011): Climate change and variability in Sub-Saharan Africa: a review of current and future trends and impacts on agriculture and food security. In *Environment, Development and Sustainability* 13 (3), pp. 587–605.

Kujala, Sari (2003): User involvement: a review of the benefits and challenges. In *Behaviour & information technology* 22 (1), pp. 1–16.

Laux, Patrick; Kunstmann, H.; Bárdossy, A. (2008): Predicting the regional onset of the rainy season in West Africa. In *International Journal of Climatology* 28 (3), pp. 329–342.

Leeuwis, Cees (2000): Reconceptualizing participation for sustainable rural development: towards a negotiation approach. In *Development and change* 31 (5), pp. 931–959.

Leeuwis, Cees (2013): Communication for Rural Innovation. Rethinking Agricultural Extension. 3. Aufl. s.l.: Wiley-Blackwell.

Lilja, Nina; Ashby, Jacqueline A. (1999): Types of participatory research based on locus of decision making. Consultative Group on International Agricultural Research (CGIAR), Participatory Research and Gender Analysis (PRGA) (No. 6).

Löhmannsröben, Raphaele (2002): Die Bedeutung des Bodens im Zusammenhang mit der hydrologischen Regionalisierung: WienerMittweilungen (164).

Malhotra, Anju; Schuler, Sidney Ruth (2005): Women's empowerment as a variable in international development. In *Measuring empowerment: Cross-disciplinary perspectives*, pp. 71–88.

Mapfumo, Paul; Adjei-Nsiah, Samuel; Mtambanengwe, Florence; Chikowo, Regis; Giller, Ken E. (2013): Participatory action research (PAR) as an entry point for supporting climate change adaptation by smallholder farmers in Africa. In *Environmental Development* 5, pp. 6–22.

Martin, Adrienne; Sherington, John (1997): Participatory research methods—implementation, effectiveness and institutional context. In *Agricultural systems* 55 (2), pp. 195–216.

McNamara, Karen Elizabeth; Buggy, Lisa (2016): Community-based climate change adaptation. A review of academic literature. In *Local Environment* 22 (4), pp. 443–460. DOI: 10.1080/13549839.2016.1216954.

Mertz, Ole; Mbow, Cheikh; Reenberg, Anette; Diouf, Awa (2009): Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. In *Environmental Management* 43 (5), pp. 804–816.

Michener, Victoria J. (1998): The participatory approach: contradiction and co-option in Burkina Faso. In *World development* 26 (12), pp. 2105–2118.

Minkler, Meredith (2004): Ethical challenges for the "outside" researcher in community-based participatory research. In *Health Education & Behavior* 31 (6), pp. 684–697.

MoFA, Ghana (2013): Agriculture in Ghana: Facts and Figures (2012). In *ed: Accra, Ghana: Statistics, Research, and Information Directorate*.

Narayan-Parker, Deepa (2005): Measuring empowerment: Cross-disciplinary perspectives: World Bank Publications.

Ndamani, Francis; Watanabe, Tsunemi (2017): Determinants of Farmers' Climate Risk Perceptions in Agriculture—A Rural Ghana Perspective. In *Water* 9 (3), p. 210. DOI: 10.3390/w9030210.

Orlove, Ben; Roncoli, Carla; Kabugo, Merit; Majugu, Abushen (2010): Indigenous climate knowledge in southern Uganda: the multiple components of a dynamic regional system. In *Climatic Change* 100 (2), pp. 243–265.

Owusu, Kwadwo; Waylen, Peter (2009): Trends in spatio-temporal variability in annual rainfall in Ghana (1951-2000). In *Weather* 64 (5), pp. 115–120.

Pretty, Jules N. (1995): Participatory learning for sustainable agriculture. In *World development* 23 (8), pp. 1247–1263.

Reed, Mark S. (2008): Stakeholder participation for environmental management. A literature review. In *Biological Conservation* 141 (10), pp. 2417–2431. DOI: 10.1016/j.biocon.2008.07.014.

Riedlinger, Dyanna; Berkes, Fikret (2001): Contributions of traditional knowledge to understanding climate change in the Canadian Arctic. In *Polar Record* 37 (203), pp. 315–328.

Rogers, Everett M. (2002): Diffusion of preventive innovations. In *Addictive behaviors* 27 (6), pp. 989–993.

Röling, Niels; van de Fliert, Elske (1994): Transforming extension for sustainable agriculture. The case of integrated pest management in rice in Indonesia. In *Agric Hum Values* 11 (2-3), pp. 96–108. DOI: 10.1007/BF01530451.

Trimble, Micaela; Berkes, Fikret (2013): Participatory research towards co-management: lessons from artisanal fisheries in coastal Uruguay. In *Journal of environmental management* 128, pp. 768–778.

White, Sarah C. (1996): Depoliticising development: the uses and abuses of participation. In *Development in practice* 6 (1), pp. 6–15.

Williams, Portia Adade; Crespo, Olivier; Atkinson, Christopher John; Essegbey, George Owusu (2017): Impact of climate variability on pineapple production in Ghana. In *Agriculture & Food Security* 6 (1), p. 26.